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IMMEDIATE AND ESSENTIAL PROBLEMS OF SOVIET SOIL SCIENTISTS[1]

I. V. Tyurin, *V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR*

The essential problems of soil scientists were primarily determined by decisions of the last plenum of the Soviet Communist Party Central Committee and by pronouncements of the twentieth Party Congress on the future development of our socialist agriculture. They were also determined by USSR Party and Government instructions on the necessity for overall development of Soviet science. Proceeding from these directives and considering the 40-year experience of Soviet soil science, we may correctly determine the most important problems for further work of national economic significance and the theoretical research connected with it to assure the continued development of our science and the creation of a "scientific resource."

In all stages of its development, especially in the Soviet period, our native soil science has participated in the solution of great national problems. The most important of these have been; 1) qualitatively listing and appraising our land resources for various purposes, especially for the development of new lands suited to agriculture, and, 2) increasing soil productivity. Both problems have essential and decisive significance for further soil science development.

The great industrial and technological strides recently made and soon to be expected, especially the colossal prospect of the peaceful use of atomic energy, cannot change the need for producing primary (plant) sources of food and other materials vital to the existence of mankind. Only through the use of vast areas of land surface may cultivated and wild plants be furnished with the solar energy, atmospheric, and soil requirements for their growth and development. The peaceful use of atomic energy undoubtedly increases the potential production of various fertilizers needed for increasing yields, and probably hastens the breeding, based on progress in radiogenetics, of better-yielding varieties of plants. But more land available for cultivation and continuous effort by men to increase soil fertility (and soil productivity in general) are still required. Therefore, the basic problems for soil scientists of the entire world will continue to be the study of soil cover by regions for establishing an inventory and developing new land resources for future agricultural production, on the one hand, and the overall investigation of soil composition and properties for working out scientific bases to increase productivity, on the other.

These problems are especially important and significant for Soviet soil scientists for two reasons: first, we utilize no more than 11% to 12% of our land for agriculture and we are still locating great areas of virgin lands which must be studied with a view to extending agriculture; second, we still have low average yields, which must be raised considerably through better utilization of the achievements of agricultural science, particularly soil science.

Along with the basic problems mentioned, we are presently confronted with a third problem of economic importance—protection of soil against widespread erosion, salinization, swamping and others—which deteriorate soil productivity.

In connection with work on problems of economic importance, it is necessary to consider the further development of experimental and theoretical investigations of soil science and methodology in relation to progress in basic and allied sciences. The success of these investigations depends on the organization of work in the soil science field. Therefore, we consider problems of national organization, among them those before the All-Union Society of Soil Scientists, its affiliates and branches.

Problems of Land Resources Inventory

A qualitative inventory of land resources is based on soil cartography. This requires a soil classification system developed on universal scientific principles. Soil classification is the basis for productivity groupings of soils—a qualitative rating of soils from the point of view of their productive use. The productivity grouping is based on soil quality, that is, economic rating, which is considered together with the economic effect of productive input (labor and material) for increasing yields.

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[1] Lecture before the First All-Union Conference of Soil Scientists of the USSR, May 12–18, 1958.

Soil cartography gives the objective basis for delineating agricultural soil regions. These are very important in planning for the general increase of agricultural productivity. Thus, a complex of problems is connected with the problem of a land resource inventory. Many Soviet soil scientists are working on the solutions.

Soil Cartography and Classification. In the area of soil cartography we can mention with satisfaction the successful completion of work on reconnaissance and detailed soil maps, covering the entire Soviet Union or large individual portions of it. Most important is the publication of the State soil map of the USSR on a scale of 1:1,000,000. The creation of this map constitutes a great scientific generalization in soil geography and classification having much organizational significance for all regional soil cartographic work carried out in the USSR by different institutions and organizations.

At present, work on soil classification and nomenclature is directed by a special interdepartmental commission of the V. V. Dokuchayev Institute of Soil Science, together with the Fifth Commission of the All-Union Society of Soil Scientists.

The commissions must work out a system of fundamental, primary taxonomic units, that is, great soil groups and sub-groups for the entire Soviet Union. For finer taxonomic units it is expedient to establish general principles of subdivision, on the basis of which local soil institutes, with the participation of affiliates and branches of the All-Union Society of Soil Scientists, must work out detailed, systematic regional lists. These activities of local soil institutes will usually be associated with the preparation of medium-scale soil maps for districts, regions, and republics which have no such maps (for example, large parts of Siberia, the Far East, and Middle Asia) or have out-of-date maps, which require revision.

A continuing problem is undertaking the vast and urgent work in detailed large-scale soil cartography. Large-scale, or detailed, soil surveys are the most extensive and agronomically important form of soil cartography. Well constructed soil-agronomic maps of individual state and collective farms serve as the only basis for prope differential introduction of measures for increasing soil fertility and land productivity. Recently the volume of large-scale soil cartography ha greatly expanded and it constitutes a basic problem for special "soil and fertilizer services."

Attention should be called to the attempts o Ukrainian soil scientists to organize large-scal cartographic work cooperatively between soi scientists and agronomists, and to group Ukrainian soils according to their productivity.

However, we must recognize several unresolved problems in detailed soil cartography which, with other causes, limit its use in our agricultural practice. The problem of the contents of detailed soil, or soil-agronomic, maps is inseparable from the problem of classification and productivity grouping of cultivated soils. This problem has great practical significance and requires further effort to define the fundamentals on which the classification and productivity grouping of cultivated soils must be based, considering the present day characteristics of our socialist agriculture (large economic units, high degree of mechanization, and so forth).

Delineating Regional Agricultural Soils. Delineation of regional agricultural soils is very important for the proper distribution of agricultural production and for working out a differential system of agriculture. At present, a basic plan is worked out for the division of the country into agricultural soil zones, sub-zones, and provinces. Further development of this plan for establishing smaller subdivisions, including regions, must be carried out by local institutions.

Soil Quality. A "new" essential problem, the treatment of which has recently attracted soil scientists, is the "old" problem of soil quality, on which V. V. Dokuchayev and N. M. Sibirtsev worked. As is known, this problem was completely neglected for several decades.

With the problems of planning and comparatively evaluating the agricultural activities of individual collective farms and regions, and the necessity for a differential approach to the collection of taxes in accord with economic and natural conditions for individual collective farms, development of a soil quality scale is urgently needed for the entire Soviet Union.

Attempts to draw up a precise quality scale, recently made in the USSR Academy of Sciences Soil Institute, may serve as an example for similar work in separate regions of the USSR. Continuation of this work requires a wide range of specialists—soil scientists, agronomists, and economists. Active discussion of this work in successive stages of its development in the affiliates and branches of the Society of Soil Scientists may contribute substantially to its successful accomplishment.

Problems of Increasing Soil Productivity

In spite of the high natural fertility of most of our agricultural soils, (judged from yields obtained with advanced management and on experiment stations), we still obtain low average yields for the planted acreage of grain and other basic agricultural crops. They are approximately forty to fifty per cent of yields obtained with advanced management. This indicates that the natural fertility of the soil is not rationally exploited on most of our planted acreage, and that the total yield of grain and other agricultural products could immediately be markedly increased by using the achievements of agricultural science and practice to raise the level of agricultural technology everywhere. At the same time the assignment set by the Twentieth Party Congress is achieved, a total grain production of 400 billion pounds and a more than doubled livestock production could be attained.

At the same time, it is necessary to assure the further development of scientific research for discovering and testing new and more effective methods of increasing soil fertility, even though new scientific achievements cannot be adopted immediately in agricultural practice.

It is basic that different methods must be used for increasing soil productivity according to soil properties and other natural conditions. But for the concrete solution of this problem, little has been done, and more persistent and purposeful work in this direction is necessary.

From the point of view of its effect on soil fertility, it is necessary to evaluate any method not only on the basis of yield, as has usually been done, but also on the basis of deeper investigations of soil processes so that sensitive quantitative data may be used to judge factors affecting yield and the direction of changes in soil fertility before they affect yield. Only thus may one reasonably decide some debatable questions of soil fertility and tillage.

Use of Fertilizers. In the advanced countries of western Europe the significant raising of yields to the present level of about 1500 kg. of grain per hectare was achieved not only from improved tillage, but primarily from fertilizers—at first (up to the end of the last century) as manure, a sufficient quantity of which was assured by the universal cropping of clover, and later from the intensive use of mineral fertilizers in addition to manure.

The experience of western European agriculture points an example for our non-chernozem regions which are similar in soil and climate to western Europe. The practice of advanced management, variety plots, and experiment stations effectively shows the possibility of obtaining the same high average yields in this area as in western Europe, using high rates of mineral fertilizers on a base of clover seedings and manure (with liming).

In V. V. Dokuchayev's time, it was considered that chernozems needed only proper soil tillage to assure accumulation and retention of moisture, and did not need fertilizers. At present, the effective use of fertilizers in the chernozem zone is expanding considerably, and earlier beliefs that fertilizer response was absent apply only to chernozems (and chestnut soils) in regions of new or recent agriculture, where the soils still retain a large supply of nutrients available to plants.

Generalization from the present data on use of fertilizers leads to the conclusion that a response is obtained on all USSR soil groups. But the effectiveness of fertilizers on different soil groups is not the same, and depends on moisture and the supply of available nutrients. The amount of this supply is determined by both soil group and length of agricultural use, which may be connected with various degrees of depletion of certain available soil nutrients. The importance of the latter factor is shown by the great response to nitrogen fertilizers, not only on podzols and gray forest soils, but also on many sub-groups of chernozems, in spite of their high total nitrogen content. Deep chernozems in old beet areas show a definite requirement for potassium fertilizers, which, as a rule, have little or no effect except on podzols and bog soils.

Thus, one of the most important problems of our soil scientists-agricultural chemists is the generalization of analytical and experimental material characterizing the content and forms of nutrients in soils, the dynamics of plant nutrients, the effect of management on nutrient availability and fertilizer effectiveness on different soils, and so forth. There is also a need to establish, in different zones of the USSR, experimental agricultural investigations on material cycles, principally for nitrogen and phosphorus. This would illuminate fundamental rules governing the evolution of soil fertility under agricultural use and help develop the scientific basis for increasing soil fertility. Another part of this work must be the study of the role of microelements in soil fertility.

Work on the chemical characteristics of USSR soils requires the use of a wide range of specialists from various institutes. For its successful completion, a single methods handbook must be supplied by the Soil Institute, USSR Academy of Sciences and the commission on soil fertility of the All-Union Society of Soil Scientists. Active attention must be given to such a handbook by the affiliates and branches of the Society.

Protection of Soils from Destruction by Water and Wind Erosion, Salinization and Waterlogging

In our vast country the best soils for agriculture—chernozems, gray forest, and dark chestnut soils—constitute only about 14%, or 300 million hectares. The reserves of virgin soils of these groups, suitable for further utilization, are comparatively insignificant. These soils constitute irreplaceable natural wealth of our country and, because they are limited in area, must be used rationally and carefully conserved from possible destruction and deterioration.

The high natural fertility of the foregoing soils is not used rationally enough. In addition, phenomena are still occurring which rapidly reduce soil quality and sometimes partially or even completely destroy it. Such, for instance, are the spreading phenomena of water and wind erosion, salinization of irrigated soils, waterlogging, and so forth.

In applying the powerful new mechanical methods of soil cultivation, the leaders of management and mechanization do not consider the conditions under which erosion arises. For example, they plowed large, continuous areas of virgin and abandoned lands with coarse textured soils which are easily subject to blowing. As a result, large new centers of wind erosion arose in the development of virgin and abandoned lands in Kazakhstan. They plowed continuous areas along slopes of silty to clay loams. This favors surface runoff and erosion during spring thaws and summer cloudbursts. Soil erosion often appears as strongly as in the days of free individual economy, and in combination with larger fields and, thus, larger water collecting areas. Consequently, it is necessary to change to plowing across slopes or even to plowing on horizontal contours.

For successful erosion control, as for an increase of yields, it is necessary to raise the general level of agricultural technology. The task must be fully realized and completed by the workers on collective and state farms with active assistance from scientific specialists—agronomists, soil scientists, agricultural chemists, and specialists in preventing soil erosion. A very important task of local soil scientists, and therefore of all local branches and affiliates of the Society of Soil Scientists, is the circulation of knowledge about the causes and consequences of erosion, rational methods of preventing erosion and combatting its consequences. At the same time, a necessary task for the specialists of scientific and experimental institutes is to develop comprehensive local and expeditionary investigations of this phenomenon and to work out rational methods of combatting it under different conditions.

The salinization of highly productive irrigated soils is very detrimental in our cotton-producing regions, since it leads to lower yields and excludes considerable areas of irrigated land from use.

The Soviet economy loses much raw cotton annually because of lowered yields from salinized soils. This loss, added to the loss in acreage excluded from agricultural utilization at various times, becomes imposing. It is important to point out that because of the unfavorable melioration status of irrigated land in particular regions, the actual increase in irrigated acreage under cotton and other crops is greatly behind the projected and planned increase. Therefore, improving the melioration status of our valuable irrigated lands is a problem of great national significance and our soil scientist meliorators must take an active part in its solution.

At the All-Union meeting on the further development of cotton culture, held last February, obligations were made to increase the cotton acreage by 582 thousand hectares and at least to double the total yield of cotton fiber. Quite obviously, the obligations can only be fulfilled by a determined struggle to restore lost fertility on abandoned lands with irrigation systems and to conduct an array of improved measures on irrigated territories to increase yields significantly.

Many questions arise in connection with the national economic tasks of increasing the productivity of bog soils, and combatting the waterlogging of non-chernozem soils.

Problems of Scientific and Theoretical Importance

The most important theoretical questions of contemporary soil science are incorporated in the problem of soil genesis. The solution to this problem rests on the comprehensive study of soil composition and properties, and on knowledge of a) enduring processes of soil profile development, b) contemporary processes of material changes and movements within the soil profile, and c) phenomena determining the dependence of soil on other natural objects—atmosphere, plants and other organisms, parent material, and ground water.

The basic goal of all investigations on soil genesis is the definition of our ideas about natural soil genesis and changes induced by cultivation. This definition must be made, not only on the basis of qualitative characteristics, but also from a quantitative accounting of all soil-forming factors in natural and cultivated soils. Soviet soil scientists have achieved much in this direction during the last decade, quantitatively evaluating several soil-forming factors and approaching the calculation of a material and energy balance in soil-forming processes.

As examples, we point out the quantitative appraisal of humus-forming processes, the work of several authors on quantitative characteristics of the geochemical role of vegetation in the accumulation of mineral elements and nitrogen, the work to clarify moisture, nitrogen, and energy balances, and so forth. It is necessary that such work, establishing soil science as an exact science, be developed and strengthened in future research.

Concerning the scope of work on soil genesis, it should be said that it is composed of the following main sections:

1. Comprehensive investigation of the composition and properties of different great soil groups (and subgroups) using the newest experimental methods.
2. Study of contemporary soil processes with standard methods.
3. Study of the genesis of great soil groups by generalizing from research in the preceding sections and establishing and developing special work.

In the study of soil composition and properties, it is to be hoped that a systematic accumulation of materials on the composition and properties of the great soil groups and subgroups will be provided on the basis of complete investigation of typical soil profiles. Until now we have very little of such comprehensive material for great soil groups. This must be considered a great gap in our knowledge. The necessary filling of this gap is the task of our commission of the Society of Soil Scientists and pedologic institutes, and chiefly of the V. V. Dokuchayev Soil Institute, which must coordinate the work on this question.

The basic substance of work on contemporary soil processes consists of standard methods of investigating the water, air, heat, and salt regimes, and also seasonal and perennial investigations of the vast cycles of transformation, movement, and exchange of organic and mineral matter within the soil profile and in the system: atmosphere—plant—soil—parent material—ground water. These investigations must be carried out on cultivated as well as virgin soils.

Special attention must be given to the comprehensive study of the role of man's economic activities in contemporary soil formation.

Study of the Genesis of Great Soil Groups. The synthetic division of this section rests on the research of the two preceding sections and, in addition, on the establishment and development of special work: studying climate in relation to the great soil groups and their regional sub-groups; studying geobotanical relationships between soils and associated vegetation, microbes and soil fauna; explaining the association of different soils with parent material; studying the role of relief in formation of soils and soil combinations in different bioclimatic zones; and ascertaining the role of man's economic activity in changing natural soil types.

Work on soil genesis problems must properly combine all basic methods of soil science, namely: the method of geographical soil investigations with analysis of soil composition and properties; the method of standard investigation of the annual and perennial dynamics of soil processes;

and the method of modeling or reproducing certain soil processes under laboratory and field conditions.

The wide range of questions and great volume of work on soil genesis problems requires the participation of all soil science institutes, both central and peripheral, and of the soil science departments of universities and agricultural institutes, using agricultural experiment stations and specially organized scientific research stations for local investigations.

Problems of Scientific Organization

There is a wide range of problems facing us. Correct alignment of strength and coordination of effort of the many existing groups of Soviet soil scientists are necessary for successfully completing outstanding work. To effect this coordination on the basis of a broad, mutual exchange of the experimental results of soil scientists in different institutions and departments, the major role must belong to the All-Union Society of Soil Scientists in the form of its Council and presidium and its affiliates and local sections.

At present there exists in the Soviet Union a large network of soil science institutions located in different systems: a) the Academy of Sciences of the USSR and the Academies of Science of the republics of the union, b) the ministry of agriculture of the USSR and the republics, including the All-Union Academy of Agricultural Sciences and those of several republics, and c) higher educational institutions—universities, agricultural academies and institutes,—in the form of soil science chairs, doing educational work chiefly, and some scientific research.

The distribution of a network of research institutions in several systems and departments has its advantages and disadvantages. The advantages are the possibilities for more complete and diverse treatment of every problem of soil science and facilitation of different approaches to their solution. These are necessary for the successful forward movement of our science and for avoiding the dangers of monopolization and one-sidedness. The disadvantages of distribution into different systems are connected with the unavoidable difficulties of coordinating the work.

We think, however, that these difficulties are not insurmountable and may be avoided by communication between representatives of different systems and mutual exchange of ideas and information at meetings of the commissions, affiliates and divisions of the All-Union Society of Soil Scientists, where soil scientists from different institutions meet as equal members of the Society.

We mention one more problem of scientific organization. In connection with the organization of the Siberian Division, Academy of Sciences, USSR, the Bureau of Biological Science and Soil Institute of the Academy of Science have raised the question of establishing an independent soil institute in Siberia. The recent spread of agriculture in Siberia and the great prospects for future use of new lands in the Siberian forest zone, with its unique soil and climate, require more intensive expeditionary and local studies of the soil cover. This may be successfully carried out only by institutions in close contact with these conditions.

Scientific Production Services in Soil Science. The question of organizing soil services in the USSR was raised four years ago in the form of a project of the Soil Institute of the Academy of Science. The project was received favorably by the scientific and technical council, Ministry of Agriculture, USSR, and obtained the unanimous support of the All-Union Society of Soil Scientists in 1954 and 1956.

Several republics—Armenia, Azerbaidzhan, Ukraine—have formed soil service organizations. In turn, the soil service of the Russian Soviet Federated Socialist Republic is now forming.

The main tasks of the soil services should be: 1) compilation of agronomic soils maps of collective and state farms as a basis for correctly organizing territories and choosing treatments to increase soil fertility; 2) qualitative accounting of agricultural land and disclosing areas threatened by water and wind erosion, salinization and waterlogging, developing measures for combatting these phenomena and controlling the execution and effectiveness of soil protective measures; and, 3) running control of soil fertility and changes in it, taking account of tillage, crop rotations, fertilization, and melioration.

The basic unit of the soil services should be the regional (district and republic) soil service center. The scientific work of soil science and agricultural chemistry departments of agricultural institutes and universities must be drawn into the work of these centers. The general scientific guidance of the work of regional soil service centers should rest with the existing central (Union and republic) and zonal scientific research institutes, in which soil divisions should be established. It follows also that lower units, such as local soil and agricultural chemistry laboratories, should be established. The regional soil centers will depend on these for carrying out massive work, especially in the running control of the status of soil fertility.

The training of a cadre of soil scientists cannot be considered fully satisfactory up to now, either from the quantity of specialists, or the quality of their training. We must hope that settling the organization of soil services will make more apparent the need for an array of methods, a flow of soil and agricultural chemistry specialists, and improvement in the quality of their training. These questions must constantly have the attention of the All-Union Society of Soil Scientists and of its affiliates and branches.

As we have tried to show, our next task consists in the simultaneous and mutually connected accomplishment of work of productive and theoretical significance. The content and direction of this work is guided by decisions of the party and government of the Soviet Union. We may be confident that the army of Soviet soil scientists will successfully handle this task. The guarantee of the further fruitful development of Soviet soil science, its creative service to the Soviet nation, and the further increase of its international power lies in naturally combining work of productive and theoretical significance, in solving the immediate economic problems, and in simultaneously creating a "scientific resource."

SOME CHARACTERISTICS OF SALT ACCUMULATION IN SOILS OF THE NORTHEAST RUMANIAN PLAIN

N. Florea and L. Stoica, *Bucharest*

An article by one of the authors of the present paper, (*Pochvovedeniye* [3]), considered the characteristics of salt accumulation in ground waters of the northeast Rumanian plain, between the Buzeu River and the Kelmetsuy Valley. The present work examines the main characteristics of the process of salt accumulation in the soils of the same area.

The analytical data of water extracts 1:5 from 240 samples, collected from 37 soil profiles, provided the material for this study. These data are presented first in the form of salt profiles according to the method of Antipov-Karatayev (1) and, second, are compared in graphs according to the proposed method by Kovda (2). In the latter case, calculation was related to the 0 to 180 cm. soil layer and to an area of 1 m^2. The 180 cm. depth corresponds to the critical depth of ground water.

The physico-geographical conditions of the area were described in the previous work (3); we therefore pass these over and go on to the conclusions which emerge from the examination of all the available material.

Amount of Salts Accumulated in Soil

As a result of salinization processes, easily soluble salts, gypsum and carbonates of calcium (and magnesium) accumulate in soils.

1. Easily Soluble Salts. In the salinized soils of the area studied, chlorides and sulphates of sodium and magnesium occur most frequently; in addition to these, very small amounts of bicarbonates of alkalis and sometimes very small amounts of sodium occur. The total amount of easily soluble salts found in the soils of the area between the Buzeu and Kelmetsuy Rivers, according to analytical data obtained in the previous work, varies from 1 to 3 kg./m.^{2} (or 30 to 80 gm. eq./m.^{2}) in the profile of non-salinized soils, up to 40 kg./m.^{2} (or about 1300 gm. eq./m.^{2}) in the soils with the highest degree of salinization (calculation carried out as previously mentioned for the 1.8 m. layer). Only in rare cases, in lake solonchaks (for instance in the solonchaks of Lacul Sărat, Braila [Lancovici, 6]), may the amount of salts accumulated the soil exceed 100 kg./m.^{2} (or 1000 metric tons per ha.). In these cases salt accumulation as a rule is not a result of soil salinization but depends on a geological process—the rising of the salt lake bottom, in which each year clay rich in salt was deposited. Lake solonchaks of this type are not considered by us because salt accumulation in them depends, both quantitatively and qualitatively, on the composition of salts dissolved in the lake water.

The highest accumulation of easily soluble salts occurs in the low areas of the relief, where the water table usually occurs at no great depth and is practically level. In depressions, there is high evaporation of ground water, particularly during the dry season in summer. Thus, in the soils and subsoils of depressions, there is accumulation of salts brought in by ground waters from the neighboring areas.

Numerous field investigations have shown a close link between the degree of soluble salt accumulation and the depth of the water table; the degree of salt accumulation increases with the decrease of the depth of the water table and with diminishing drainage. This is illustrated by Figure 1. When the water table is deeper than 3.5 to 5 m. the soil's salt content is very low, and there is practically no salt accumulation. When the depth of the water table is less than 3.5 to 5 m. a trend toward a certain accumulation of salt appears. This is sharply intensified with a water table depth of 2 to 2.5 m; the latter depth corresponds to the critical level of soil salinization, while the first depth is generally subcritical, as it was in the area examined by Florea (3, 4, 5). As the figure shows soils with low salt accumulation exist with a high water table also; but these cases are explained either by the short duration of the salinization processes or by good ground water run-off (in the latter case, strongly salinized soils are not formed).

2. Gypsum. According to available analytical data, easily soluble salts are always accompanied by gypsum. Gypsum accumulates in fa naller amounts than easily soluble salts. Usu- lly the gypsum content amounts to 0.5 to 2 g./m.² when the content of easily soluble salts less than 8 to 10 kg./m². Only in the case of ore salinized soils does the amount of gypsum radually increase to 10 to 15 kg./m². We found nly one case (lake solonchak) in which the mount of accumulated gypsum (86 kg./m.²) reatly exceeded the amount of easily soluble alts (12 kg./m.²). In this soil, the horizon rich- st in gypsum contained more than 17% of it.

The degree of gypsum accumulation is also inked with the depth of the water table (Fig.). The correlation between these two indices is ess clear than in the case of easily soluble salts, ut it is still sufficiently distinct. As it is gener- lly similar to that discussed previously we shall ot consider it in detail.

3. Carbonate of Calcium (and Magne- ium). Calcium and magnesium carbonates (we xpress them conventionally as $CaCO_3$) may also e deposited in salinized soils from ground wa- ers, either together with other salts or forming separate accumulation horizon. The data show o differences in $CaCO_3$ content in salinized and on-salinized soils (in which $CaCO_3$ usually ccurs). The amount of $CaCO_3$ is in both cases 00 to 400 kg./m.² (in the 1.8 m. layer). In the rea studied there is no relationship between the mount of $CaCO_3$ accumulated in the soils and he depth of the water table, except for the zone f leached chernozems where there is a clear ecrease in the amount of $CaCO_3$ in soils with a water table occurring deeper than 4 to 5 m. This results from intensified leaching of $CaCO_3$ rom the soil profile.

Soil Accumulation of Various Easily Soluble Salts

Examination of the analytical and graphical data on the qualitative composition of salts ac- cumulated in soils led to the conclusion that in the area studied two regions are distinguished. The boundary between them runs along the line Enchi Valley to Lishkotyanka. These regions differ in the nature of their salt accumulation.

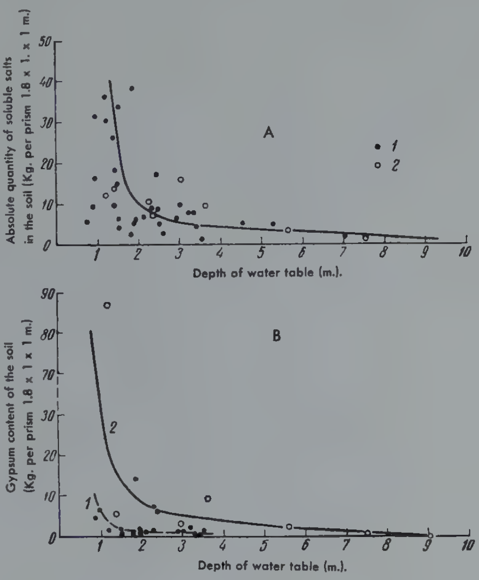

FIG. 1.—A—Relationship between total content of easily soluble salts in the soil and depth of ground waters (area between the Buzeu and Kel- metsuy rivers). 1—Central and western part; 2— eastern part. B—Relationship between total gyp- sum content in the soil and depth of ground waters. Area between the Buzeu and Kelmetsuy rivers.

Figure 2 shows the salt profiles of the most prevalent soils in the first region—the central and western part of the area between the Buzeu and Kelmetsuy rivers. These profiles clearly indicate a predominance of NaCl in the soluble salt composition. As the curves show, changes both of absolute and of relative Na^+ and Cl^- content are extremely similar. They differ clearly from other ions. This indicates the predominance of NaCl in the soluble salt composition in the salinized soils of the region studied. The curves of the variation of absolute and relative Na^+ content always run higher than the curves of the Cl^- content. This indicates that not only chloride salts of sodium are present, but also others—sodium sulphate and, possibly, sodium carbonate (in the case of slightly salinized soils). Sodium chloride and sodium sulphate predominate in the salt composition of salinized soils. This causes the emergence of the sodium sulphate-chloride salinization of this area. In the most highly salinized soils, a certain amount of $MgSO_4$ is also observed in the salt composition. Gypsum also accumulates frequently, as previously mentioned. Calcium bicarbonate is hardly ever found in salinized soils. Sodium bicarbonate (and sometimes also carbonate) occurs in larger amounts in soils with a low degree of salinization (for which the curve of HCO_3^-

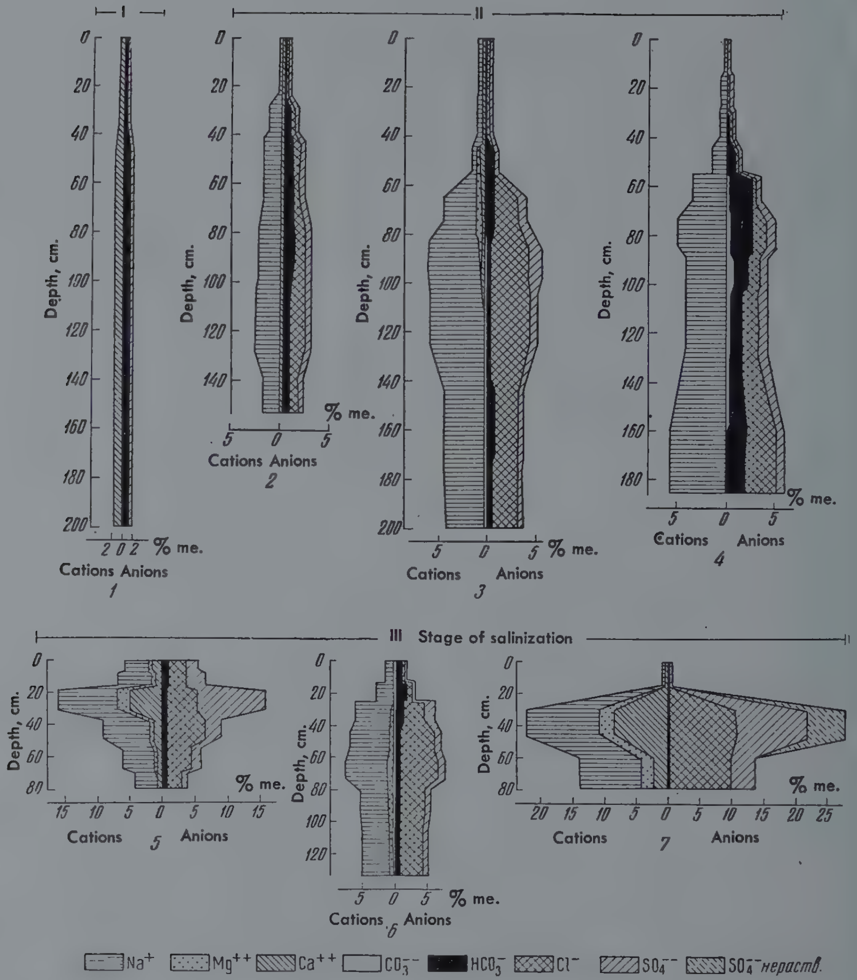

FIG. 2.—Saline soil profiles of the central and western parts of the area between the Buzeu and Kelmetsuy rivers. 1—Meadow chernozem (6-4851 south of Feur); 2—solonetz (5-I XIX south of Surdila Grech); 3—meadow chernozem (3-I XIX, Surdila Grech station); 4—solonetz (4-t XIX southeast of Chilibiya station); 5—solonetz (0.1 southeast of the Buzeu); 6—solonetz (49-I XIX, south of Surdila Grech); 7—meadow salinized chernozem (38-4951, northeast of Berlesht).

content occurs considerably higher than the Ca^{++} curve).

A detailed examination of the Figures shows the stages in the salt accumulation process; it is possible to distinguish on the salinization curve several sections or several stages of soil salinization, analogous to the stages of ground water mineralization (established by V. A. Kovda) characterised by different chemical composition of salts. Thus, the data of water extracts shov the following successive stages of soil salinizatio in the western and central parts of the area between the Buzeu and Kelmetsuy rivers.

The first salt accumulation stage correspond to a salinization of less than 3 kg. of solubl salts per square meter (practically non-salinize soils), with a predominance of calcium bicarbonate.

The second salt accumulation stage represents a salinization of 3 to 7 kg. of soluble salts per square meter (which corresponds generally to solonchak-like soils). It is characterised by mixed salinization by anions (among which sometimes bicarbonates and sometimes chlorides predominate) and by sodium cations salinization.

The third stage, beginning when the soluble salt content is higher than 8 to 10 kg./m.^{2} (it corresponds generally to solonetzes, solonchaks and even some strongly solonchak-like soils), is characterised by a predominance of sodium chloride and also sodium sulphate in the salt composition.

The first soluble salt accumulation stage may be termed the calcium-bicarbonate stage. The second stage is the mixed stage, in which sometimes sodium-chloride-bicarbonate salinization and sometimes sodium-bicarbonate-chloride salinization occur. The last salt accumulation stage is the sodium-sulphate-chloride stage. We note that the second soil salinization stage is characterised not only by the salts previously mentioned but also by the occurrence of sodium carbonate (Na_2CO_3) in some soils.

Figure 3 shows salt profiles of salinized soils of the eastern region, that is the eastern part of the area between the Buzeu and Kelmetsuy Rivers. Here, an accumulation of sodium sulphate takes place. As the curve of the variation of Na^+ content (both absolute and relative) is always higher than the curve of the SO_4^{--} content, side by side with Na_2SO_4 in the salt composition, there are other sodium salts in considerable quantities, namely sodium chloride (this is made still more evident by the fact that part of the SO_4^{--} occurs in the soil in the form of $MgSO_4$). This determines the sodium-(sodium-magnesium) chloride-sulphate salinization, typical of this region. Bicarbonates, which appear in small amounts, are found only in soils containing more than 10 kg. of salts per square meter, in the form, moreover, of calcium bicarbonate (according to the data of water extracts). This can be seen from a comparison of the two curves of relative HCO_3^- and Ca^{++} content for soils of this salinization type. In the case of soils containing less than 10 kg. of salts per square meter (according to the data of water extracts), when the curve of the variation of the relative Ca^{++} content occurs below the curve of the HCO_3^- content, sodium bicarbonate and, possibly, magnesium bicarbonate appear side by side with calcium bicarbonate.

Both this and the previous case show the laws governing the change in salt accumulation composition in relation to the increase of their total content, and consequently show the presence of stages of salinization in the process of soluble salt accumulation. In the eastern part of the area between the Buzeu and Kelmetsuy rivers (according to the data of water extract analysis) the following successive stages of soil salinization are distinguished: 1) the calcium-bicarbonate stage, characteristic of non-salinized soils containing less than 2–3 kg./m.^{2} of soluble salts; 2) the stage of mixed salinization by anions and of sodium salinization by cations, characteristic of soils containing 3–7.5 kg./m.^{2} of soluble salts; 3) the sodium stage (sodium-magnesium chloride-sulphate) of salinization (sodium sulphate predominates, while considerable amounts of sodium chloride also occur) appears in soils with a soluble salt content higher than 7.5 kg./m^2.

The existence of these two regions having different types of salinization indicates the presence of different natural, particularly hydrogeological, conditions in the two parts of the area between the Bezeu and Kelmetsuy rivers.

Judging by the literature data, the occurrence of a region with chloride-sulphate salinization is unusual for these bioclimatic conditions, and is explained on the one hand by the ground water effect in this area, where chlorides markedly dominate the composition and on the other hand, by the almost complete absence of outflow, which favors the chloride accumulation. In the eastern part of the area between the Rivers, where the drainage of the Duna is manifested, a slow outflow of the most soluble salts and especially of chlorides takes place, resulting in considerable sulphate accumulation.

Salt Accumulation in Surface Layer of Solonchaks and Saline Crusts

In this region, for which we possess more analytical data, the soluble salt content in the surface layer of solonchaks reaches 4 to 6.5%, and in saline crusts of solonchaks the total content of soluble salts and gypsum may exceed 37%. In all cases SO_4^{--} predominates markedly in the anion composition, amounting to 40% of the total salt quantity (and never falling below

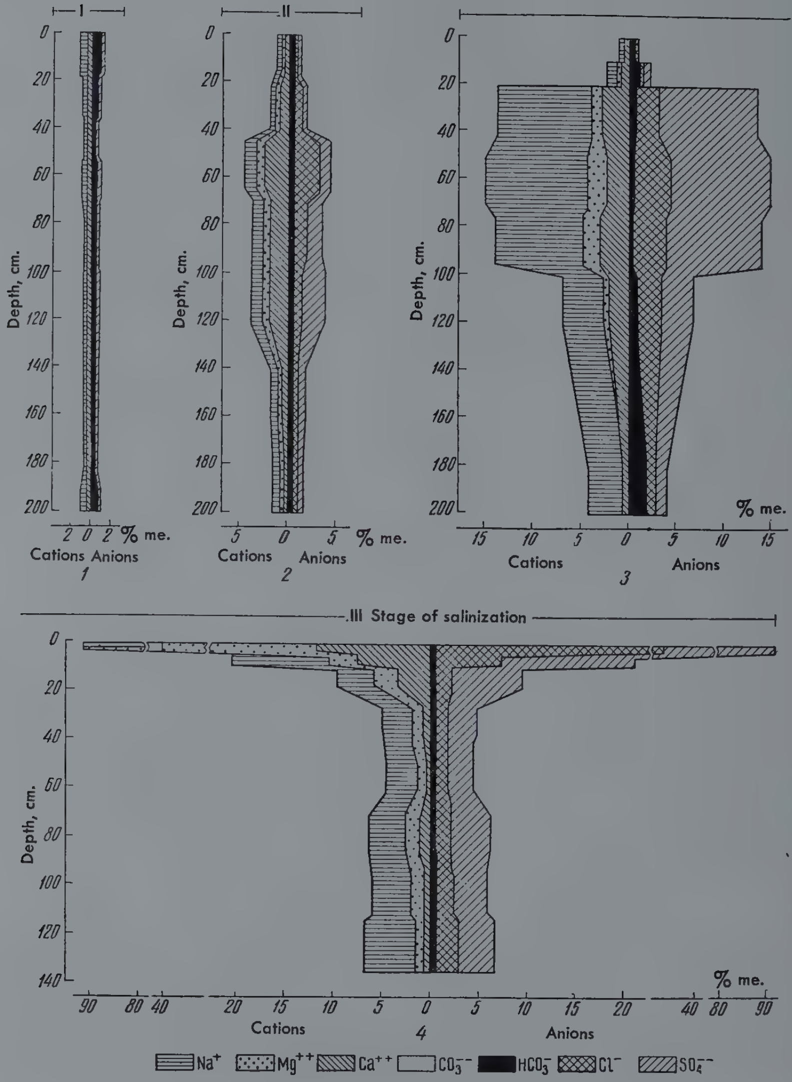

FIG. 3.—Saline soil profiles of the eastern part of the area between the Buzeu and Kelmetsuy rivers. 1—Chernozem (4-5252 Lacul Sărat); 2—meadow salinized chernozem (1-5151, south of Osman); 3—meadow salinized chernozem (183-5452, west of Tikilesht); 4—solonchak (4-5050, Valya Enchi).

30%); next in order comes the Cl^- and the HCO_3^- is found in extremely small quantities. Among the cations, the Na^+ predominates (28 to 46%); then follows Mg^{++} (3 to 15%) or Ca^{++} (3 to 16%). In soils containing a large amount of gypsum the Ca^{++} may predominate. The salts which appear in the crusts and superficial horizons of solonchaks are thus sodium sulphate, magnesium sulphate, sodium chloride and calcium sulphate.

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AN EXPERIMENTAL STUDY OF THE LEACHING PROCESS OF SOLONCHAK-LIKE SOLONETZES[1]

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THE Dzhanybek Field Station of the Forest Institute, where our experiments were carried out, is in the northwest lowlands adjoining the Caspian Sea, 30 km. north of Lake El'ton.

The natural conditions of this region are unfavorable owing to the dry climate and the widespread occurrence of solonchak-like solonetzes, associated with a plain between two depressions. The inter-depression plain, occupying about 85% of the whole area, has a well-expressed microrelief. The main elements are: microelevations occupying 50 to 60% of the inter-depression plain, microdepressions amounting to 20 to 50%, and microslopes from the elevations to the depressions comprising about 25%.

With general flatness and evenness, the variation in height among the separate elements of the microrelief reaches 30 to 40 cm.; this provides a local surface redistribution of thawing waters, and directly causes the complexity of the plant and soil cover and of soil-ground waters.

The agricultural rise of the plains is possible if the solonchak-like solonetzes are ameliated.

The morphological profile of solonchak-like solonetzes consists of the following horizons: 1) the upper solonetz horizon 5 to 10 cm. thick; 2) the solonetz horizon 20 to 40 cm. thick, in the lower part of which there are accumulations of readily soluble salts; 3) the first sub-solonetz horizon 50 to 70 cm. thick, characterized by permanent low moisture (11 to 12%), by a peculiar pseudo-sandy structure, by low bulk density (1 to 1.2 gm./cm.^{3}) and by the presence of gypsum in the surface part; and 4) the second sub-solonetz horizon differing from the horizon above it in its greater compactness and in a gradual increase in moisture content with depth. Its thickness is 100 cm.; below this it gradually passes into soil-forming parent material—loess-like fine clay loam. The water regime of solonchak-like solonetzes (1, 3) is related to the leached type and is characterized by shallow soaking during spring which includes only the upper–solonetz and the solonetz horizons (Fig. 1, right).

The salt profile of solonchak-like solonetzes is illustrated in the left part of Figure 1. There are few salts in the upper-solonetz horizon and in the surface part of the solonetz horizon. From the lower part of the solonetz horizon downwards the salt content increases rapidly, forming a maximum (2.5 to 3%) including the first and second sub-solonetz horizons. This maximum extends to a depth of about 2 m. SO_4^{--} predominates in the anion composition of the whole profile, and Na^+ in the cation composition. There are fewer magnesium than calcium salts. The maximum Cl^- content coincides with the maximum Na^+ content. High alkalinity (1.2 to 2 me.) resulting from carbonate and bicarbonate ions is characteristic of the solonetz horizon. The alkalinity decreases with depth to a fraction of me.

The exchange capacity is 17 to 18 me. in the upper-solonetz horizon; in the solonetz horizon and in the upper part of the first sub-solonetz horizon it is 20 to 24 me., and is correlated with the silt content.

The profile of solonchak-like solonetz is fairly homogeneous in its texture, although a reduced silt content is found in the upper-solonetz horizon and an increased content in the solonetz horizon and the upper part of the first sub-solonetz horizon. The exchangeable sodium content is 5 to 12% of exchange capacity in the upper-solonetz horizon and 30 to 60% in the solonetz horizon and in the underlying horizons.

From the foregoing characteristics of solonchak-like solonetzes, we believe that their reclamation should be based on simultaneous desalinization and desolonetzization. Both these processes require additional water. In the absence of irrigation this can be secured through accumulation of snow from forest and shrub shelterbelts.

As was shown by Kovda and Bol'shakov (4) gypsum is indispensable for desolonetzization. It occurs in solonchak-like solonetzes of the

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[1] Presented at section meeting of the conference of soil scientists.

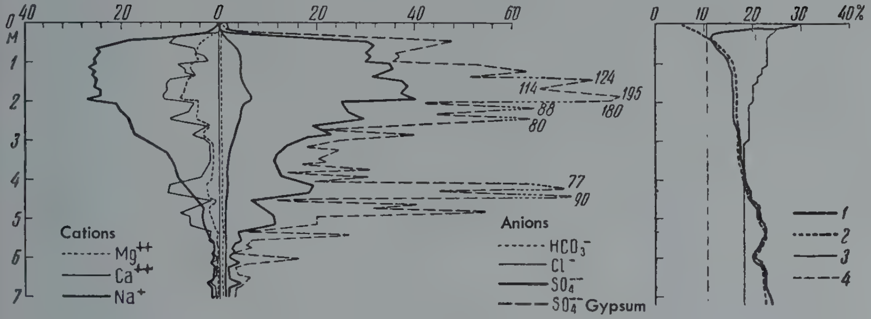

FIG. 1.—Virgin solonchak-like solonetz. Salt profile (me.) and moisture profile. 1—Spring; 2—autumn; 3—minimum water-holding capacity; 4—wilting moisture.

Dzhanybek region at a depth of 35 to 50 cm. below the surface. It can be utilized for reclamation by means of deep plowing which brings it up to the cultivated layer.

Our experiments were made with the aim of studying the processes of desalinization and desolonetzization of solonchak-like solonetzes by means of deep plowing and additional watering. In order to carry out this study more quickly and more accurately (excluding the possible influence of soil variation) we used special monoliths. These consisted of soil prisms of 1 m.^{2} in area and 1 to 2 m. high, isolated laterally by concrete or parchment but preserving contact with the underlying ground.

The experiments were carried out in 1952, 1953 and 1954. The aim of the 1952 experiment was the elucidation of the salt leaching rate and the laws governing it when evaporation is absent. In 1953–1954 we studied the leaching of salts and their opposite, from different depths in the presence of evaporation or plant transpiration.

Incidentally, it became clear what effect is exerted on the ascent of salts and moisture by the soil surface condition (compacted or loose). Altogether, 30 monoliths were set up, of which one (No. 1) had an undisturbed soil profile structure. All the remaining were spaded to the depth of 50 cm. with careful mixing. By this mixing we imitated the deep plowing used for bringing gypsum up to the cultivated layer. The layout of the experiments carried out on monoliths at the Dzhanybek Field Station is given in Table 1. After the first irrigations all the monoliths were covered up on the 15th day. After this time 5 replicate samples were taken by means of an auger from the 10 cm. layer of each monolith to determine moisture and salt content. The auger holes were carefully filled with salt-free moist clay. The monoliths on which there had been successive irrigations were then ready for subsequent leaching.

In the present paper space limits us to dealing with the most characteristic monoliths and only touching on the remainder. Such characteristic monoliths are Nos. 1, 3, 4, 5 and 13 (see Table 1).

The study of desalinization and desolonetzization processes carried out by us on monoliths 1, 2, 3 and 13 included:

1. Study of water extract composition by means of which we determined *a*) salt content and *b*) salt supply.
2. Study of soil solution composition.
3. Study of the composition of exchangeable cations.
4. Determination of the sum of SO_4^{--}.

In the remaining monoliths the study of the desalinization processes was limited to the analysis of water extracts and the determination of the sum of SO_4^{--}.

To characterize the chemical composition of the soils studied, in Table 2 we give the salt content according to the data of water extracts, concentration of soil solutions and composition of exchangeable cations for the virgin solonchak-like solonetz (monolith no. 1) and for the spaded solonchak-like solonetz (monolith no. 3).

There were different rates of water intake during leaching (experiments of 1952, Table 3). The slowest intake rate was in virgin solonchak-like solonetzes (monolith no. 1). During the first irrigation an uneven soaking of the soil was observed. Part of the water passed through cracks in the solonetz horizon beyond the line of the 1 m. layer. During successive irrigations, after the

TABLE 1

Layout of experiments on the leaching solonchak-like solonetzes

Monolith number	Year of experiment	Depth of monolith, m.	Nature of cultivation	Number and amount of irrigations, mm.	Crops	Object of experiment
1	1952	1	Virgin solonchak-like solonetz	5–100	None	Laws governing movement of salts during leachings in the absence of evaporation
2	1952	1	Spaded to a depth of 50 cm.	" "	"	
3	1952	2	"	5–250	"	
4	1953	1.5	Same, surface compacted	1–150	"	Laws governing movement of salts during leachings in the presence of evaporation
5	1953	1.5	" loose	1–150	"	
6	1953	1.5	" compacted	1–250	"	
7	1953	1.5	" loose	1–250	"	
8	1953	1.5	" compacted	1–350	"	
9	1953	1.5	" loose	1–350	"	
10	1953	1.5	Spaded to a depth of 50 cm.	1–150	Sudan grass	Laws governing movement of salts during leachings in the presence of evaporation and transpiration
11	1953	1.5	"	1–250	"	
12	1953	1.5	"	1–350	"	
13	1952	1	"	5[a]		

Note: During the whole experiment (summer 1952) monoliths 1, 2 and 3 were covered with shields and tarpaulins to prevent evaporation.

[a] Two of them 100 mm. each, one 130 mm., and two 150 mm. each.

TABLE 2

Composition of water extracts, of soil solutions and of exchangeable cations in virgin and spaded solonchak-like solonetzes

Monolith number	Depth, cm.	Water extracts, milliequivalents									Soil solutions, milliequivalents									Exchangeable cations as % of exchange capacity	
		Dry residue	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	$\frac{Na^+}{Ca^{++}}$	Dry residue	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	$\frac{Na^+}{Ca^+}$	$Ca^{++} + Mg^{++}$	Na^+
1	0–5	0.04	None	0.6	0.1	Traces	Traces	Traces	0.7	—	2	None	12	4	15	10	9	13	1	90	10
	5–10	0.10	0.3	1.2	0.3	"	"	"	1.9	—	3	"	12	28	17	21	6	31	1	71	29
	10–20	0.41	0.4	1.1	1.9	3.1	"	"	6.5	—	17	"	14	101	151	26	23	217	8	48	52
	20–30	2.47	0.1	0.3	4.8	31.7	11.5	3.1	22.3	2	45	"	10	240	442	34	91	568	17		
	30–40	2.72	None	0.2	5.9	34.5	12.3	4.6	23.7	2	51		8	263	547	33	121	663	20	55	45
	40–50	2.70	0.1	0.2	6.8	33.4	10.3	4.8	25.4	2											
	50–60	2.80	None	0.2	7.7	34.1	10.1	5.0	26.9	3	63	"	8	319	635	35	131	796	23	15	85
	60–70	2.48	0.1	0.2	6.8	30.2	8.2	4.7	24.3	3											
	70–80	2.12	0.1	0.3	7.1	24.5	3.8	3.7	24.8	6	57	"	6	327	571	34	142	728	21	21	79
	80–90	2.21	0.1	0.3	7.6	25.6	3.8	4.3	25.4	7											
	90–100	2.11	0.1	0.3	8.0	23.5	2.4	3.6	25.9	11	61	"	6	327	611	34	138	772	23	44	56
3	0–5	1.0	None	0.4	2.5	12.3	4.6	1.6	9.0	2	22	"	10	109	226	40	34	272	7	55	45
	5–10	1.0	"	0.4	2.5	12.3	4.6	1.6	9.0	2	22	"	10	109	226	40	34	272	7	55	45
	10–20	1.0	"	0.4	2.5	12.3	4.6	1.6	9.0	2	22	"	10	109	226	40	34	272	7	55	45
	20–30	1.0	"	0.4	2.5	12.3	4.6	1.6	9.0	2	22	"	10	109	226	40	34	272	7	55	45
	30–40	1.0	"	0.4	2.5	12.3	4.6	1.6	9.0	2	22	"	10	109	226	40	34	272	7	55	45
	40–50	1.0	"	0.4	2.5	12.3	4.6	1.6	9.0	2	22	"	10	109	226	40	34	272	7	55	45
	50–60	2.5	"	0.2	5.3	32.2	13.3	5.2	19.1	1	55	"	8	228	518	33	120	601	18	23	77
	80–90	2.4	"	0.2	6.8	29.3	7.6	4.6	24.0	3	55	"	8	279	557	40	140	664	17		
	110–120	2.8	"	0.1	7.2	34.8	12.4	5.4	24.2	2	57	"	8	293	573	42	136	697	17	28	72
	130–140	2.7	"	0.1	6.6	33.3	13.0	5.4	21.6	2	57	"	8	299	582	39	144	706	18		
	160–170	2.8	"	0.1	7.1	34.4	13.3	5.0	23.2	2	59	"	8	319	585	39	138	735	19	19	81
	190–200	2.5	"	0.2	5.5	31.8	13.5	4.5	19.4	1	47	"	8	247	472	30	94	602	20	42	58

TABLE 3

Duration of water absorption (hours) during successive leachings of the monoliths

Monolith number	No. 1					No. 2					No. 3				
mount of water given during irrigation	100	100	100	100	100	100	100	100	100	100	250	250	250	250	250
umber of successive leachings		2	3	4	5	1	2	3	4	5	1	2	3	4	5
uration of water intake (hours)	14.40	35.00	31.00	31.30	33.00	2.10	7.15	5.15	6.00	9.15	2.50	9.00	6.00	19.45	20.15

racks had closed, water intake took place evenly nd much more slowly. A decrease in the intake ate with each successive irrigation was also oted for spaded solonetzes. This was linked with he consolidation of the first sub-solonetz horion during the leaching of easily soluble salts.

At the beginning of the leachings there was an ncrease of alkalinity resulting from both carbonte and bicarbonate ions. The most stable inrease of alkalinity was observed in the solonetz orizon of virgin solonchak-like solonetzes. The emaining ions were progressively leached out oth in the virgin and the spaded solonetzes. The hloride ion was leached out most rapidly. In orler to leach out the latter completely from the 1 n. layer of virgin solonetz (monolith no. 1), 400 nm. of water were needed; for the 1 m. layer of paded solonetz (monolith no. 2) 300 mm. of waer were required for the same purpose. Chloride ons were removed from the 2 m. layer of spaded olonetz (monolith no. 3) after 3 irrigations totaling 750 mm.

The sulfates were leached out slowly during eaching, mainly in the form of sodium and magnesium sulfates (Table 4). After 5 irrigations totalling 1250 mm. in the upper 80 cm. layer of spaded solonetz (monolith no. 3), no soluble sulfates (Na_2SO_4 and $MgSO_4$) were left. At the lower irrigation rate (500 mm.) in the virgin solonetz in the first sub-solonetz horizon, approximately one fifth of the original content of soluble sulfates remained.

The calcium content varied to a lesser degree during leachings; this is associated with the low solubility of gypsum.

The magnesium content of water extracts decreased markedly after the first two irrigations. From the beginning of the third irrigation it hardly changed at all, amounting to approximately two fifths of the original content. This behavior on the part of the magnesium ion can be explained by the fact that after leaching the main mass of its soluble salts, the ionic exchange reactions between the soil solution and the adsorbed complex became very important. Calcium entering into the adsorbed complex replaced an equivalent amount of magnesium. This resulted in the stability of the content of this ion in the water extracts. The lowest degree of leaching of the sodium ion (in the absence of evaporation) was noted in the virgin solonetz.

Variation in the salt content during leaching showed that their removal already takes place during the first leaching, although the moisture of the lower part of the layer under treatment did not reach the minimum water-holding capacity. This indicates that the part of moisture which percolated during the first irrigation through the cracks below the line of the 1 m. upper layer removed a certain amount of salts, "expelling" part of the soil solution. Figure 2 gives the salt profiles of solonetzes leached 1) in the absence of evaporation and 2) with evaporation and transpiration. The greatest variations in the content of Cl^-, SO_4^{--}, Na^+ and Mg^{++} occurred in the spaded solonetz at the high irrigation rate (1250 mm.)

In order to characterize the processes occurring during the leaching of solonchak-like solonetzes in greater detail, we studied the composition of the soil solutions (initial concentrations are given in Table 2). Soil solutions in the virgin solonetzes are sharply differentiated along the soil profile (Table 2). Their lowest concentration is in the upper-solonetz horizon and in the surface of the solonetz horizon. The highest is in the first sub-solonetz horizon. The main component in the soil solution of the first sub-solonetz horizon is sodium sulfate. In the spaded solonetzes of the upper 50 cm. layer the composition of soil solutions is leveled out.

During leachings, a decrease in the concentration of all ions except Ca^{++} was observed. The greatest variations of ion concentration were observed in spaded solonetz receiving the high irrigation rate (1250 ml.).

The high sodium salt content affected the composition of the exchangeable cations. A study of the variation in their composition during leac ings showed that the smallest changes occurred the virgin solonchak-like solonetz in its first sul solonetz horizon, where the exchangeable sodiu content decreased to 15 to 45% (before the irr gations it was 30 to 80%, Fig. 3, *a*).

TABLE 4

Variation in the content of sulfates of different solubilities during leaching of spaded solonetz (Monolith No. 2), me. per 100 gm. dry soil (Rate of leaching 1250 mm.)

Depth, cm.	Before Leaching				After 5 leachings			
	Total SO_4^{--}	SO_4^{--} passing into water extract at 1:5	Calcium from gypsum	Sulfates of Na & Mg	Total SO_4^{--}	SO_4^{--} passing into water extract at 1:5	Calcium from gypsum	Sulfates of Na & Mg
0–5	20.22	12.32	7.90	7.74	3.80	2.12	1.68	None
5–10	20.22	12.32	7.90	7.74	3.20	1.18	22.02	"
10–20	20.22	12.32	7.90	7.74	3.80	1.87	1.93	"
20–30	20.22	12.32	7.90	7.74	3.55	1.81	1.74	"
30–40	20.22	12.32	7.90	7.74	3.55	1.64	1.91	"
40–50	20.22	12.32	7.90	7.74	5.55	2.25	3.30	"
50–60	56.73	32.22	24.51	18.90	10.27	5.64	4.63	0.11
60–70	61.14	31.88	29.26	20.22	10.68	7.54	3.14	0.29
70–80	65.58	31.55	34.03	21.32	11.03	8.41	2.62	0.54
80–90	61.44	29.27	32.17	21.65	11.33	6.15	4.18	0.50
90–100	56.57	30.85	25.72	20.78	13.64	8.35	5.29	2.20
100–110	60.83	34.02	26.81	21.33	19.85	10.45	9.40	3.39
110–120	75.20	34.78	40.42	22.40	21.06	9.60	11.46	3.27
120–130	71.38	31.69	39.69	21.56	21.06	12.12	8.94	3.91
130–140	57.89	33.26	24.63	20.27	28.21	12.68	15.53	4.30
140–150	67.40	33.71	33.69	20.26	25.34	12.43	12.91	3.87
150–160	75.49	32.31	43.18	21.77	44.15	16.42	27.73	6.23
160–170	70.23	34.40	35.83	21.10	70.18	20.22	49.96	7.10
170–180	75.80	33.24	42.56	19.48	86.19	22.44	63.75	7.93
180–190	70.23	30.98	39.25	19.68	68.61	21.55	47.06	6.70
190–200	68.37	31.82	36.55	18.34	63.61	19.08	44.53	7.10

Spading the upper 50 cm. layer secured a mo even water intake, and (most important of all brought gypsum up into the cultivated layer. Fo this reason, after the fourth leaching of monolit No. 3 (when the total amount of irrigation wate reached 1000 mm.), exchangeable sodium was re tained in the upper 80 cm. layer to the level o 4 to 5% of exchange capacity, while before leach ing its content reached 40 to 60% (Fig. 3, *b*).

Experiments with physical evaporation (1953 1954) were laid down in order to elucidate it effect on the reverse, ascending movement o salts, leached out to a different depth by differen irrigation rates. There were 3 rates of irrigation 150, 250 and 350 mm. The monoliths, as men tioned previously, were in pairs: one with a com pacted surface, the other with a loose surface. A the 150 mm. irrigation rate the soil was wetted t 120 cm.; at 250 and 350 mm. it was wetted t more than the whole depth of the layer studied that is, to more than 1½ m. The moisture los from evaporation is given in Table 5. It reache a remarkable value (36 to 78 mm.); althoug loose soil surface lowered this value only slightl (4 to 12 mm.). Evaporation took place from th upper 1 m. layer.

We investigated the effect of evaporation o the reverse, ascending movement of the chlorid

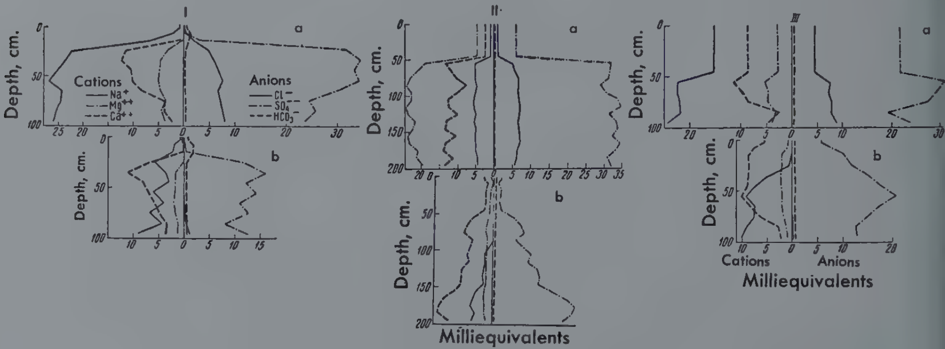

FIG. 2.—Salt profiles of solonchak-like solonetzes. I. Virgin solonchak-like solonetz, monolith no. 1: a—before leachings; b—after leachings, rate 500 mm. II. Spaded solonchak-like solonetz, monolith no. 3: a—before leachings; b—after leachings, rate 1250 mm. III. Spaded solonchak-like solonetz with Sudan grass, monolith no. 13: a—before leachings; b—after leachings, rate 630 mm.

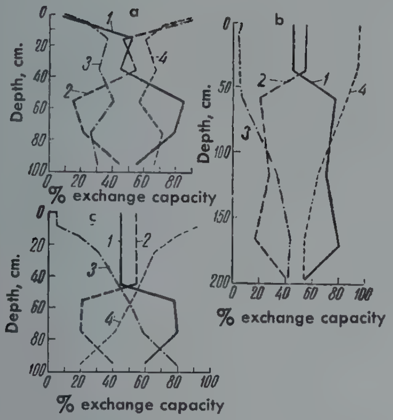

FIG. 3.—Effect of leaching on the composition of adsorbed cations. a—Virgin solonetz, rate 400 mm.; b—spaded solonetz, rate 1000 mm.; c—spaded solonetz with Sudan grass, rate 630 mm. 1—Na^+ before leaching; 2—$Ca^{++} + Mg^{++}$ before leaching; 3—Na^+ after leaching; 4—$Ca^{++} + Mg^{++}$ after leaching.

ion—the most mobile of all anions. At the irrigation rate of 150 mm. the chloride ion was leached to 50 cm. During subsequent evaporation, clearly expressed translocation of chlorides into the upper layers was observed. The same was noted also at the 250 mm. irrigation rate, when the chloride ion was leached to a depth of 80 cm. The 350 mm. irrigation rate leached Cl^- beyond the line of the 1 m. layer, and we did not observe its return during evaporation. On the contrary, the Cl^- content continued to decrease. This was associated with the flow of gravitational water in the soil.

Another object of our experiments was the elucidation of the effect on the ascent of salts during leaching when transpiration took place. For this purpose Sudan grass was sown after the irrigations on solonchak-like solonetzes spaded to a depth of 50 cm. Both single irrigations (150, 250 and 350 mm.) and repeated (5 irrigations totalling 630 mm.) were applied.

The moisture content at the 150 mm. irriga-

TABLE 5

Moisture contents and losses for physical evaporation with different irrigation rates in solonchak-like solonetzes with compacted and loose surface (mm. of water)

Layer, cm.	Monoliths								
	No. 4 (150 mm.)			No. 5 (150 mm.)			No. 6 (250 mm.)		
	Compacted			Loose			Compacted		
	15 days after leaching, June 26th	End of experiment, Sept. 15	Balance	15 days after leaching, June 26	End of experiment, Sept. 15	Balance	15 days after leaching, June 27	End of experiment, Sept. 16	Balance
0–50	153	123	−30	150	128	−22	153	120	−39
50–100	134	119	−15	133	119	−14	153	132	−21
100–150	118	123	+5	117	112	+5	156	148	−7
0–150			−40			−36			−67
Difference in value of moisture loss						4 mm.			

Layer, cm.	Monoliths								
	No. 7 (250 mm.)			No. 8 (350 mm.)			No. 9 (350 mm.)		
	Loose			Compacted			Loose		
	15 days after leaching, June 27	End of experiment, Sept. 16	Balance	15 days after leaching, June 28	End of experiment, Sept. 17	Balance	15 days after leaching, June 28	End of experiment, Sept 17	Balance
0–50	156	127	−29	149	119	−30	149	127	−22
50–100	161	132	−29	176	144	−32	171	148	−23
100–150	156	152	−4	164	148	−16	168	147	−21
0–150			−62			−78			−66
Difference in value of moisture loss			5 mm.						12 mm.

TABLE 6

Variation in moisture reserves in the layers as affected by evaporation and transpiration by Sudan grass (mm. of water)

Layer cm.	Monolith No. 10 (150 mm.)				Monolith No. 11 (250 mm.)				Monolith No. 12 (350 mm.)			
	After leaching, June 26	Aug. 10	Sept. 15	Balance	After leaching, June 27	Aug. 11	Sept. 16	Balance	After leaching, June 28	Aug. 12	Sept. 17	Balance
0–50	165	81	77	88	172	93	80	92	165	88	76	89
50–100	121	100	99	22	151	126	100	51	158	116	86	72
100–150	105	109	108	43	152	140	130	22	173	152	136	37
0–150	391	290	284	107	475	359	310	165	496	356	298	198

tion rate at the moment when Sudan grass was sown amounted to 391 mm. in the 1½ m. layer. Loss of moisture by evaporation and transpiration was observed in June and July and amounted to 100 mm. It was observed mainly in the upper ½ m. layer (88 mm.; Table 6). The moisture did not change subsequently, as in August the amount of available water in the 0 to 50 cm. layer was fully depleted.

The upper limit of chloride presence, which was leached to a depth of 60 cm. with this irrigation rate, moved 20 cm. upwards as a result of evaporation and transpiration.

At the 250 mm. irrigation rate the moisture consumption under Sudan grass was observed also in September; the drying out included the whole 1½ m. layer. Chlorides leached out at the beginning of the experiment to a depth of 80 cm. moved 20 cm. into the upper layers.

At the 350 mm. irrigation rate 496 mm. depth of water was created in the 1½ m. layer, exceeding the value of the minimum water-holding capacity. Moisture consumption was observed during the whole experiment, and drying out included the 1½ m. layer. Part of the moisture consumption in the 80 to 100 cm. layer, where gravitational water accumulated during irrigation, should be attributed to run-off. Chlorides, leached to a depth of 130 cm. in the second 1 m. layer, moved upwards. This was not observed in experiments without vegetation.

In the experiment with repeated irrigations, 5 irrigations totalling 630 mm. were applied during the summer. During the whole experiment the moisture content in the upper ½ m. layer was lower than the minimum water-holding capacity, and in the second ½ m. layer, it was close to this value. The presence of evaporation and transpiration during the repeated irrigations slowed down but did not stop the progressive leaching of chlorides (Fig. 2, III); the main amount was leached after the second irrigation.

The leaching of sodium and magnesium sulfates, although it had a progressive trend, was slower than in experiments without evaporation. On the whole, the salt profile under grasses changed after leaching, but not as significantly as was observed for the solonchak-like solonetz, leached under conditions of an absence of evapo-

TABLE 7

Comparison of concentration of Cl^- and SO_4^{--} in soil solutions (experiments without evaporation and with evaporation and transpiration)

Depth, cm.	Monolith No. 3 (1250 mm.)						Monolith No. 2 (500 mm.)						Monolith No. 13 (630 mm.)					
	Evaporation prevented												Crop of Sudan grass					
	Dry matter, gm./l.		Cl^-, me.		SO_4^{--}		Dry matter, gm./l.		Cl^-		SO_4^{--}		Dry matter gm./l.		Cl^-, me.		SO_4^{--}	
	Leaching		Leaching		Leaching		Leaching		Leaching		Leaching		Leaching		Leaching		Leaching	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
0–5	22.0	2.3	109.0	1.0	226.3	20.8	35.9	3.2	201.0	2.1	346.0	40.7	26.6	11.0	193.0	4.0	213.8	120.0
10–20	22.0	2.7	109.0	1.0	226.3	30.9	35.9	4.7	201.0	2.1	346.0	62.8	26.6	11.7	193.0	6.1	213.8	148.5
30–40	22.0	4.1	109.0	1.0	226.3	51.4	35.9	5.7	201.0	2.1	346.0	73.7	26.6	12.2	193.0	5.9	213.8	154.3
50–60	Not determined						56.2	6.2	291.0	2.1	558.6	87.1	55.0	16.0	286.9	3.0	550.2	217.9
60–70	"	"	"	"	"	"	57.4	7.1	307.1	3.1	565.6	91.7	52.2	22.8	290.9	3.0	507.3	299.4
70–80	55.6	5.0	279.0	1.0	556.7	66.2	58.3	8.5	321.1	5.1	569.4	114.8	50.5	22.2	303.0	6.9	473.7	301.9
90–100	56.8	6.1	293.0	1.0	573.0	82.7	72.6	9.4	403.9	10.2	718.1	123.5	57.5	25.6	355.5	10.9	510.6	346.6

ation and transpiration (Fig. 2, III). A study of he composition of soil solutions under grasses howed that concentrations of Cl^-, SO_4^{--}, Na^+ nd Mg^{++} remain higher during leaching under udan grass. The decrease in the Na^+ and SO_4^{--} oncentration was particularly slight—only 2 imes—while without evaporation it decreased 10 imes (Table 7).

The greatest changes in the composition of exhangeable cations under grasses were noted for he 1 to 10 cm. layer. In the deeper layers these hanges are smaller; this is associated with the eneral slowing down of the process of salt leachng (Fig. 3, *b*).

Conclusions

1. Solonchak-like solonetzes, even virgin, are haracterized by a relatively high intake rate. During leaching, uneven wetting of the soil proile, owing to cracks, is observed at the beginning.

2. Deep plowing, which brings gypsum up into he cultivated layer, increases the water intake rate approximately 4 times. During leaching the ntake rate decreases; this is explained by soil welling, by closing of the cracks and by the compaction of the sub-solonetz horizon when easily oluble salts are leached from it. Even at the end of leaching, however, the intake rate remained higher in plowed solonetzes.

3. The leaching waters percolating through the oil replace part of the soil solution. Saturation of the soil with moisture up to the minimum water-holding capacity favors the dissolving of alts which occur in the solid state. Each succesive leaching replaces a new part of soil solution. The qualitative composition of salts changes durng leaching in the direction of an increase in the alcium content.

4. The first leachings of 100 and 250 mm. produced only a redistribution of salts within the 1 n. and 2 m. layers respectively. Two successive eachings by the same amount of water produce a complete leaching of chlorides from these layers. Sulfates are leached more slowly than chlorides.

5. Bringing gypsum up into the cultivated ayer and the irrigation rate of 1250 mm. produce desalinization and desolonetzization of the upper 1 m. layer. The exchangeable sodium content decreased to 4% to 5% of exchange capacity in the case of an initial content of 40% to 60%. An increase of alkalinity of plowed solonetzes during leaching is observed at the beginning of leachings, and is replaced subsequently by a decrease.

6. The composition of soil solutions of solonchak-like solonetzes changes along the profile. Leachings result in a considerable decrease in concentrations of all ions excluding the calcium ion, the concentration of which remains constant for a long time as a result of the presence of gypsum. Towards the end of leaching, the concentration of soil solutions at the irrigation rate of 500 mm. in the 1 m. layer, under conditions of the absence of evaporation, decreases by 10 times. In the presence of evaporation at the irrigation rate of 630 mm. it decreases by two times in the same layer.

7. Loosening the surface of solonchak-like solonetzes, particularly at the moment of highest moisture, decreases the moisture loss by evaporation, but by only 4 to 12 mm., with a total consumption of 36 to 78 mm. With evaporation the reverse, ascending movement of leached Cl^-, SO_4^{--} and Na^+ is observed. It is expressed most strongly when salts occur at a depth of 50 to 80 cm. from the surface. Transpiration produces an ascent of salts from the second 1 m. layer. On fallowed plots at this depth of leaching the ascent of salts is not observed.

8. Evaporation and transpiration retard the leaching of salts.

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THE ROLE OF AFFORESTATION IN DECREASING SALINITY OF IRRIGATED SOILS

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The present study was carried out at the Valuy meliorative experimental station (Staraya-Poltava region, Stalingrad district) during June, 1949, in forest plantations located near a homestead on the bank of Solënaya Kuba River. The forest stand was planted here in 1900 in light-chestnut solonetz and heavy clay solonetz.

For 30 years prior to 1930, the forest was artificially irrigated twice a year; after this date, irrigation was discontinued. At present, the forest strips consist of common elm, Tartar maple, yellow acacia, buckthorn, and *Halimodendron argenteum*. Distances between trees are 1 m., between rows 2 to 3 m. Height of trees is: elm and maple, 4 to 5 m.; buckthorn, 3 m.; yellow acacia, 2 to 3 m. The latter branches into 25 to 30 main stems.

For field studies pit borings were made leading down to ground-water level near the main species of trees used for afforestation (the elms, maples and yellow acacia [at 0.5 m. distance]), and also near a control strip of virgin area located 45 m. away from the forest plantations and 30 m. from the rim of Solënaya Kuba River.

Afforestation practiced over a long period (49 years) had a marked effect on soil properties. In the plot under forest plantations, no solonetz areas were found; but in the adjacent virgin area, the surface soil consisted of over 50% solonetz. The thickness of horizon A increased from 20 to 23 cm. as compared to only 14 cm. on virgin area. The soil acquired some resemblance to chernozem—the gradual merging of horizons, the stable granular structure of horizon A. In the plot of virgin area, the structure of horizon A remained lamellate—typical of light-chestnut solonetz soils. All the general characteristics of salinity are very pronounced on virgin area but tend to disappear in afforested areas.

Morphological features clearly show the difference in saline profile of soils under forest and under virgin area. In forest plantations, the carbonate horizon is 15 to 16 cm. lower. This horizon is diffuse, grayish-white, and sometimes resembles thin mycelium threads. Apparently, there is a replacement of gypsum with calcium carbonate; this is also evidenced by the indistinct outlines of the horizon where sulfates are secreted in mass quantities. The sulfate layer is 140 to 170 cm. lower, while on virgin area there is a double layer of maximum sulfate accumulation. The first layer is close to the surface (15 to 36 cm.), the second lies at a depth of 115 to 220 cm. Thus, field examination shows the effectiveness of forest plantations in desalinization of soils. Chemical analysis furnishes even more convincing proof (Table 1).

Compared with virgin area soils under forests are very low in water-soluble salts, especially within depth limits of the first meter. The total of water-soluble salts in the ground near the maple and the elm at this depth is not over 0.22%; near the acacia it is up to 0.66%. In virgin area, at a depth of 16 cm. to 2 m., the water-soluble salts content fluctuates from 1.16 to 1.9%. Chlorides are most subject to leaching.

Forest plantations had no effect on soil reaction. The pH remains the same within the alkaline and slightly alkaline interval; general alkalinity is higher in soils under forest than in fallow soil. This is due to a better solubility of calcium and magnesium carbonate under conditions of higher humidity and higher saturation with carbon dioxide in the soil solution, resulting from the activity of the root systems of trees. It is quite likely that the movement of carbonates in soils under forests tends to decrease the solonetz content in the process of desalinization of these soils. Sulfates that resist solubility react in the same way (Table 2).

Both chemical analyses and field studies show that there is a high gypsum content in virgin soils, and that there are two horizons of its maximum accumulation. The distribution of gypsum within the soil profile indicates that a leaching of both easily soluble and less soluble salts takes place beneath the forest plantations. Within the limits of the first meter, the gypsum content of these salts is not over 0.17%, while in virgin soil it is up to 2.53%. From a depth of 200 cm. and to the water table, the gypsum

TABLE 1

The pH, water-soluble compounds and SO_4^{--} of gypsum in dry soil, percent

Depth, cm.	pH	Total salts	Cl^-	SO_4^{--}	SO_4^{--} of gypsum	Depth, cm.	pH	Total salts	Cl^-	SO_4^{--}	SO_4^{--} of gypsum	Depth, cm	pH	Total salts	Cl^-	SO_4^{--}	SO_4^{--} of gypsum
Near maple and elm						Near acacia						Virgin area					
0–13	7.3	0.06	0.002	None	0.01	1–13	7.1	0.12	None	None	0.05	0–10	7.3	0.08	0.003	0.01	0.03
25–35	7.5	0.08	0.001	None	0.16	24–35	7.5	0.07	0.001	0.01	0.16	16–25	7.5	1.52	0.214	0.80	2.53
39–45	7.7	0.08	0.001	0.01	0.06	40–46	7.5	0.09	0.007	0.01	0.13	29–35	7.5	1.91	0.341	1.07	1.10
50–56	7.5	0.09	0.006	0.01	0.13	54–60	7.7	0.31	0.209	0.02	0.07	39–46	7.7	1.83	0.348	0.88	1.31
70–76	7.5	0.19	0.015	0.10	0.12	100–106	7.5	0.65	0.323	0.07	0.17	55–61	7.7	1.18	0.337	0.52	0.21
100–106	7.5	0.22	0.010	0.12	0.15	150–156	7.5	0.66	0.112	0.12	0.21	92–98	7.5	1.42	0.355	0.65	0.93
140–146	7.5	1.59	0.010	0.70	3.18	200–205	7.1	1.14	0.078	0.66	1.34	115–121	7.3	1.85	0.149	1.07	2.19
195–200	7.3	1.41	0.004	0.90	2.95	230–260	7.5	0.64	0.036	0.41	0.57	200–206	7.5	1.16	0.009	0.76	2.01
210–240	7.3	1.44	0.009	0.92	2.51	280–305	8.3	0.27	0.028	0.15	0.14	230–260	7.3	0.11	0.009	0.04	0.08
240–270	7.3	1.59	0.014	0.98	2.85	325–355	8.3	0.27	0.028	0.12	0.20	290–325	7.7	0.10	0.009	0.05	0.17
280–325	7.3	0.52	0.025	0.30	0.38							320–365	7.5	0.10	0.007	0.07	0.16
												360–385	7.3	0.10	0.007	0.04	0.15

content of soils under forests is higher than that n virgin area because of leaching in the upper ayer.

Values for salt contents in kg. per cubic meter (Table 2) illustrate the process of desalinization n soils planted to forest.

The salt content is 160 to 278 kg. higher in virgin soil than in forested soil, as shown in a 3 m. prism with a cross-section 1 m. This difference in salt contents of the two soil types is most pronounced in the first meter: in forest plantation plots the salt content is not over 22.5 kg. in a prism, while in virgin soil it is as much as 155.7 kg., of which 34.7 kg. is chloride.

The distribution of salts with depth is also characteristic. In virgin soil their minimum content including chloride occurs in horizons 200 to 300 cm. deep, while their maximum content is located higher at 100 to 200 cm., as seen in the present salinity profile. In contrast is the typical desalinized profile of soils under forest plantations; here salinity increases gradually in the downward direction.

Soils in plantations are not uniform in quantity or type of salt content even over short distances (50 to 100 cm. in our instance); they are influenced by the biological properties of woody plants. Under maples and elms the soil contains 14 times less chloride at a depth of the first meter than under acacia plantations where the increase in salt content is mostly sulfuric acid. Although salinity is higher under the maples and elms than under the acacias, soil conditions are better in the first case, because under acacias the chloride concentration becomes toxic (0.21%) at a depth of 60 cm. Such differences in the salt composition of soils in plantation are attributable to structural differences in the root systems of woody plants and to physiological differences in root nutrition. It is known that yellow acacia develops its densest root spread in the uppermost half-meter of soil, and it is this soil layer that becomes most desalinized. As a legume, the yellow acacia absorbs more calcium and sulfate ions through its roots than the maple or elm. This probably accounts for some decrease in

TABLE 2

Water-soluble salts in the soils of Valuy district, kilograms per cubic meter

Location of pit boring	Depth, cm. From	Depth, cm. To	Total salts	Cl^-	SO_4^{--}	Ca^{++}
Near maple and elm	0 100 200	100 200 300	13.1 116.5 140.2	0.8 1.1 1.0	4.3 21.1 77.1	2.0 19.4 22.8
Total	0	300	269.8	2.9	102.5	44.2
Near acacia	0 100 200	100 200 300	22.6 42.1 86.0	11.4 26.1 3.1	1.2 5.1 52.0	2.8 5.2 12.8
Total	0	300	151.1	40.6	58.3	20.8
Virgin area	0 100 200	100 200 300	155.7 222.5 51.6	34.7 17.9 1.1	81.1 128.6 8.7	13.6 32.8 3.5
Total	0	300	429.8	53.6	218.4	49.9

TABLE 3

Chemical composition of underground water in forest plantation and in virgin area. Valuy district, percent

Location of pit boring	Depth of underground water, m.	Dry residue	Alkalinity		Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+ by difference, me.
			CO_3^{--}	HCO^-					
Near maple and elm	3.1	6.33	0.01	0.44	0.65	3.08	0.57	0.30	36.91
Near acacia	3.5	7.54	0.03	0.53	0.90	3.46	0.18	0.22	79.81
Virgin area	3.8	1.77	0.01	0.22	0.17	0.75	0.25	0.05	7.94

TABLE 4

Data on bulk density, porosity and water intake in soils under forest plantations and in virgin area

Horizon	Bulk density	Porosity, %	Water intake, cc. per sec.	Bulk density	Porosity, %	Water intake, cc. per sec.	Bulk density	Porosity, %	Water intake, cc. per sec.
	Near maple and elm			Near yellow acacia			Virgin area		
A	1.21	54.5	1.68	1.12	55.56	1.40	0.29	50.00	0.11
B_1	1.30	49.0	0.12	1.30	48.21	0.39	1.39	47.60	0.06

amounts of these elements in the soil profile. Forest plantation leached out the salts from the soil and increased their content in subsoil water. It also raised the water table by 40 to 70 cm. (Table 3).

The subsoil water under forest plantations tripled or quadrupled its previous mineral content, mostly by chlorides and sodium sulfate which were added from the soil profile in the leaching process.

Soils in forest plantations are more effectively desalinized through better use of irrigation and rainwater. Porosity and permeability improve under a forest cover (Table 4).

In the plot of virgin area permeability of horizon A is 15 to 16 times less, that of horizon B_1 is 21 to 67 times less than in forest plantation areas. The low permeability of virgin soil has little relation to porosity (since the latter is only about 10% lower) but depends mostly on salinity and stability of structure. Field observations have shown that under forest plantations the granular soil structure and the symptoms of salinity are lessened while on virgin area the structure is fragile, loosely lamellate, and distinctly saline. Improvement in the soil's permeability through afforestation in the dry Southeast i evidently associated with profound physio-chemical changes that are brought about by change in water regime and in type of plant cover.

The grass vegetation of Valuy forest planting consists of Festuca and Agropyrum mixed-gras associations. Predominant among them ar grasses and some multiple-grass representative of the more northward steppes: Bromus an Artemisia—and also those requiring more water paniculate wormwood and absinthe. These grow in a close, well-developed stand. The wormwoo and the grass-wormwood associations of th adjacent steppe have only a few grasses in thei floristic makeup—here they differ from the Festuca association that grows under a forest cover Owing to lack of water xerophytic semi-desert plants predominate—white wormwood, Kochia and so on. Wormwood and pyrethrum plant associations have been replaced by gramineous and leguminous plants, and as stated by V. A. Kovda "have completely eradicated salinization through biological transformation and self-melioration o soils, a process that has been called the taming of solonetz" (3).

The important biological role of plants in desalinization owes much to the root nutrition o plants. Roots bring in calcium from the nonsaline horizons. Studies by Antipov-Karatayev (2), Shikhova (6), Ratner (4, 5), Aydinyan (1) and others show that in the process of ash exchange between soil and plants there is a constant renewal of absorbed ions resulting in an increased calcium and decreased sodium content in the adsorption complex. The sodium is taken up from the adsorption complex into plant tissues; when tissues die the sodium is more effectively leached out than calcium compounds.

Jenny and collaborators (8, 9, 10) have devised a theory based on observations of a contact exchange between root systems of plants and soil colloids. Mack Drake (7) and other investigators came to the same conclusions.

It is probable that forest trees take a more active part than grasses in the reactions described. An increase in activity of carbonates and calcium sulfates in areas under forest plantation also has a beneficial effect on the soil profile.

Conclusions

1. Data from Valuy experiment station show that plantings of common elm, Tartar maple

ellow acacia, buckthorn, and *Halimodendron* *rgenteum* can be successfully grown in soils oorly suited for forest stands—light chestnut, lkaline (solonetz) clay-loam and solonetz soils —if irrigation is provided at least during the irst years of growth.

2. A stand of trees of many years' duration vill cause substantial changes in the morphologi-al, physical and physicochemical properties of oils. The effect of afforestation is such that the oil is self-meliorated and desalinized. Combined vith irrigation, this treatment can be successful n the reclamation of solonetz soils.

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DELINEATION OF REGIONAL AGRICULTURAL SOILS AS DEMONSTRATED IN SOUTHEAST ESTONIA

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In view of the great area and variety of natural and economic conditions in the Soviet Union, the delineation of regional agricultural soils serves a number of purposes and is carried out on various scales. It should, however, be based on definite and generally accepted principles. An appropriate classification scheme, determined by its make-up and comprehensiveness, should be used. The principles of delineating regional agricultural soils are clearly and thoroughly presented in the publications of Rozov (8), Gorshenin (1) and Letunov (3). But there still remains a great diversity both in the taxonomic nomenclature used and in the contents of individual classification schemes, as P. A. Letunov has pointed out. A still greater inconsistency is to be found in publications on regional soils, in spite of the fact that, here, the contents of individual classification schemes frequently corresponds to the concept of regional agricultural soils. The diversity is particularly great in the case of the distinctions used in more detailed classification schemes; the same parts of an area being designated differently in the publications of different investigators. Thus, Lillema (4, 5, 6), on the basis of his many years' work, distinguishes regional soils (in their make-up, agricultural soils) in the Estonian SSR, while Ufimtseva (11), regionalizing the northern sod-podzolic subzone, designates the same regions sometimes as regions and sometimes as subregions. Such inconsistency in regionalization units is shown in greater detail in the publications of P. A. Letunov.

In order to promote the utilization of the results of agricultural soil regionalization carried out under the various conditions of the territories of the USSR, and in order to avoid unnecessary deciphering of individual classification schemes, it is essential to work out a well-defined taxonomic nomenclature of agricultural soil regions and to define clearly the contents of each individual classification. This is particularly important for the more finely distinguished agricultural soil regions, since every soil scientist has to cope with the current distinctions between them, owing to the very rapid development of soil research in all the republics and provinces. The use of the same taxonomic nomenclature for denoting different contents causes great misunderstandings and can hinder the rapid development of agriculture. A distinct agricultural soil region, unique in its extent and contents, should consistently be given the same taxonomic nomenclature.

The classification system for regional agricultural soils we used was worked out on the basis of the factors which condition the development of defined and mutually related soil groups within a given area and the corresponding measures for agricultural development. In the case of small-scale regionalization, natural and geographical conditions are considered first of all, and the classification units employed correspond to the units recommended by Letunov (3). In the case of more detailed regionalization within small administrative units, attention is mainly directed, on the basis of general natural conditions, towards specific agrotechnical, hydroameliorative and organizational measures.

The largest units should perhaps be *agricultural soil zones* (four altogether, according to N. N. Rozov), separated on the basis of natural and geographical zones. Within agricultural soil zones are separated *agricultural soil subzones*, which are subdivided on the basis of local macroclimatic conditions into *agricultural soil provinces*. Detailed characteristics of these subdivisions in the agricultural soil regions of the USSR are contained in the publications of N. N. Rozov. In accordance with variations in the geological structure of areas within the provinces, *agricultural soil districts* are distinguished.

All these classification units are extremely large and embrace considerable sections of the country. An agricultural soil district, for instance, may embrace a number of administrative subdivisions (republics, regions, and so forth). Naturally this may occur in the case of finer classification units also under the same natural conditions.

Agricultural soil regions, distinguished on the asis of their combined soil elements developed nder the influence of characteristics of the rea's geomorphological make-up, could be the ext subdivision. As soil cover and its agricultural utilization may develop differently under he same geomorphological conditions, depending on the different texture and chemical composition of the soil-forming rocks, it often beomes necessary to subdivide agricultural soil egions further into *agricultural soil subregions.* hese must also be subdivided, on the basis of arious combinations of soil forms with different moisture conditions, into *agricultural soil icroregions,* which are the most important diisions in large-scale delineation of agricultural oil regions. Although microregions are the smallst subdivisions in the general classification sysem, they may still embrace a considerable secion of territory within administrative units. As he delineation of agricultural soil microregions based mainly on the defined combination of oil forms of a given area, the most important, undamental document is the detailed soil map. his is the indispensable basis for differentiating ith sufficient accuracy the necessary agrotechical, hydro-ameliorative and organizational easures, for instance, in administrative regions r in separate sections within districts or reublics.

Agricultural soil microregions may further be ivided into *agricultural soil massifs,* on the asis of characteristics of agrotechnical or other easures (for instance, on the basis of lime reuirement of soils, according to their similarity s regards the growing of alfalfa, and so forth). he agricultural soil massifs themselves consist f the smallest units of all—actual *soil contours* –requiring different types of soil cultivation, ifferent rates of fertilizer (including lime) and ifferent agricultural crops.

In distinguishing any classification unit in elineating agricultural soil regions the main grotechnical, hydro-ameliorative and agricultural-economic measures for agricultural development should be indicated. The more detailed he regionalization, the more detailed (and, acordingly, more specific) must be the recomendations for agricultural practice. More study hould be given to the problem of specialization f agricultural undertakings in all the distinct lassification units, particularly in the subdiviions above microregions.

Delineation of Agricultural Soil Regions of Southeastern Estonia

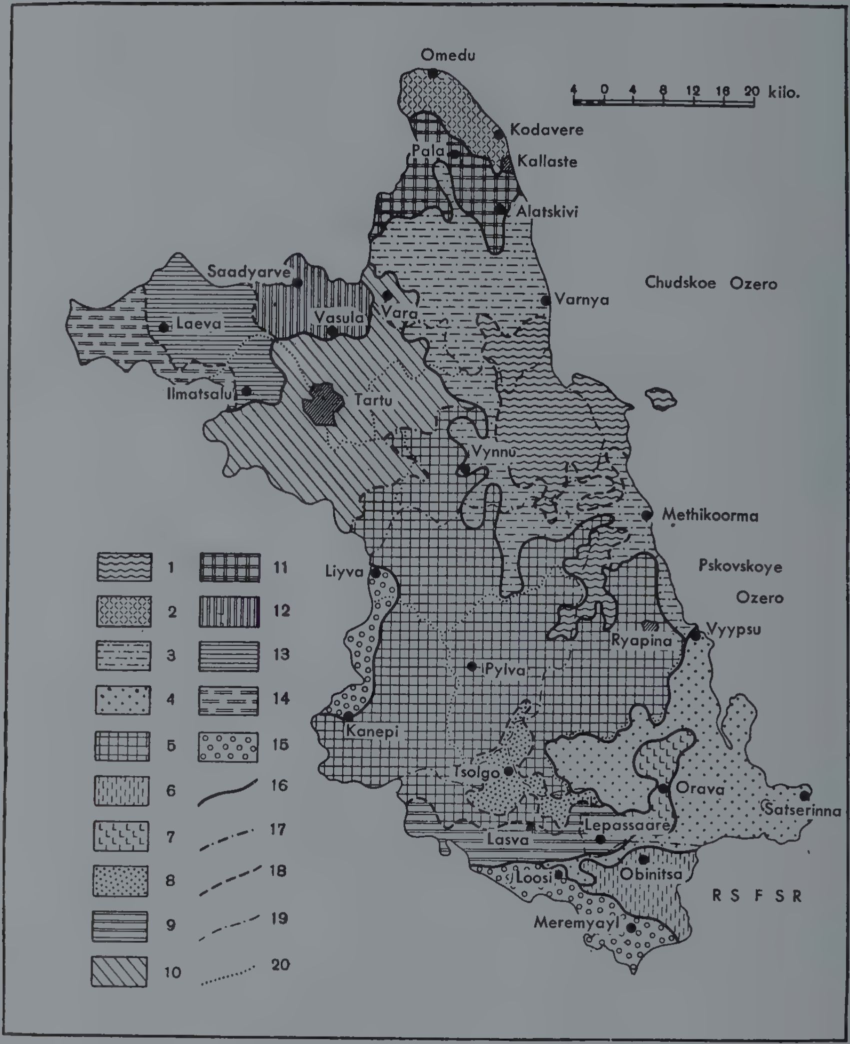
In the classification system suggested by N. N. Rozov, the Estonian SSR is included in the south-Baltic agricultural soil province of sod-podzolic, sod-carbonate and half-bog soils. It is related to the agricultural soil subzone of sod-podzolic and bog soils of the agricultural zone of podzolic soils of the forest-meadow zone.

On the basis of geology the Estonian SSR is divided into two agricultural soil districts: 1)—the district of sod-carbonate, sod-gley saturated and bog soils overlying Silurian rocks (northern Estonia), and 2)—the district of sod-podzolic, podzolic-bog and bog soils overlying Devonic rocks (southern Estonia).

In the publications of Lillema (4, 5, 6) the territory of our republic is divided into eight soil (agricultural soil) regions, each of which is subdivided into a number of subregions (19 in all). As a criterion for this division Lillema used soil combinations of elements defined by geomorphological make-up and soil-forming rocks.

Delineation of agricultural soil regions in greater detail should be based on the data of deeper research into natural factors and soil characteristics. The first results of detailed regionalization of this kind based on data from the study of soils of the Tartu region (Reyntam and Rooma, 7) have already proved their value, and agricultural soil microregions distinguished by this means are used as a basis for agricultural economy (Teytel'baum, 10). Economic studies, still unfinished, are being carried out in the Vyrusk (Sarv, 9) and Ryapina regions (Lilover) on the basis of agricultural soil microregions.

The basis of the present study is the large-scale soil map of southeastern Estonia prepared as a result of seven years' (1951–1957) work, using data from detailed soil maps covering approximately 75% of its area. This great work was done mainly by students of the agricultural faculty of the Estonian Agricultural Academy under the guidance of the lecturers in the departments of soil science, agricultural chemistry and agriculture, and also by the workers in the soil division of the Board of Agricultural Organization, Estonian Ministry of Agriculture. The operational direction of the whole work ensured a comparatively high standard in the data obtained. In addition, a number of check routes



Outline Map of the Agricultural Soil Microregions of Southeastern Estonia (prepared by L.Yu. Reyntam)

Region of podzolic, podzolic-bog and bog soils of the Lake Peipus area. Microregions: 1—delta of the Ema and Meelva Suursoo rivers; 2—Kodavere-Omedu; 3—Varn'ya-Vynnu-Mekhikoorma; 4—Vyypsu-Satserinna. *Region of sod-podzolic soils of southern Estonia.* Subregion of sod medium-podzolic and strongly podzolic soils (Pyl'va-Ryapina). Microregions: 5—Akh'ya-Pyl'va-Ryapina; 6—Obinitsa; 7—Orava; 8—Tsolgo; 9—Lasva-Lepassaare. Subregion of sod slightly-podzolic soils (Tartu-Vil'yandi). Microregions: 10—Tartu-Vara; 11—Alatskivi-Pala. *Region of Sod-carbonate leached and podzolized soils of central Estonia.* Microregions: 12—Saad"yarve-Vazula; 13—Laeva-Il'matsalu; 14—river system Ped'ya-Laeva. *Region of sod-podzolic eroded soils of morainic hillocks.* 15—Loosi-Meremyaye and Liyva-Kanepi microregion. Boundaries: 16—of agricultural soil regions; 17—of agricultural soil subregions; 18—of agricultural microregions; 19—of administrative regions; 20—of Machine and tractor service station zones.

were carried out and many supplementary data characterizing the soil cover were collected.

The area studied occupies 4564.8 km.^{2} (73.4% of it in agricultural land), spread over six administrative regions.

Its climate is fairly uniform: the mean annual temperatures fluctuate between +4.2 and +4.7°, and the amount of precipitation is 490 to 663 mm. (depending on the year). About 40% of the total precipitation falls during the period from July to September (harvest time). There is comparatively little precipitation at the beginning of the growing period. The amount of precipitation in May and June is only 20% of the annual total. As evaporation in May exceeds precipitation by 14%, plants are often insufficiently supplied with water during this period. Over the year, precipitation is greater than evaporation; therefore a downward flow of water and, associated with it, the process of podzol-formation, predominate in soils. This is favored also both by the nature of the vegetation and by the low cation content (carbonates) of he soil-forming rocks. As a result of retarded run-off of ground waters and stagnant surface waters, bog formation develops intensively in the depressions of the relief (under conditions of relatively long autumns and winters) and many half-bog and bog soils occur.

The area studied embraces four agricultural soil regions, distinguished by Lillema. The natural conditions and the soils of these regions and of the subregions and microregions distinguished within them, will be examined below, as well as the measures necessary for agricultural development in this area.

Table 1 gives data on the occurrence of soils, the make-up of the agricultural land of the collective farms and the area of excessively moist and acid cultivated soils in the agro-pedological microregions of southeastern Estonia.

Region of Podzolic, Podzolic-Bog and Bog Soils of the Lake Peipus Area

Up to now in this region only the subregion of sod-podzolic, podzolic-gley, sod-gley and bog soils has been studied, occupying approximately 4% of the total area investigated. Mesodevonic deposits covered by a morainic layer are the original rock here. To the north of the Kodavere-Assikvere line (1.6% of the whole area) only Siluric limestone occurs deep under the moraine, but does not exert any significant effect on the soils. The relief is sloping-undulating, plain-like; narrow ridges (banks of water-glacial origin and coastal terraces) occur in places on sloping elevated plains, and morainic hillocks alternate with half-bog lowlands and bogs. The soil-forming rocks are gravelly water-glacial sands, early-lake sorted sands and silty sandy loams, overlying carbonate-free or slightly carbonate clay loam moraine and in places overlying sloping hillocks and banks, and sandy morainic clay loam effervescing locally deeper than 80 cm. In view of the predominance of double-layered drifts, the surface waters stagnate on underlying clay loam, and as a result of water in the upper layer the majority of soils often have an excessive moisture content and are exposed to intensive gleying and podzolization. Thus, half-bog (with a varying degree of podzolization) and bog soils predominate here, requiring fundamental improvement—particularly drainage and liming. A considerable area is occupied by natural meadows, but they are insufficiently utilized and their productivity is low. The requirements of livestock, therefore, make it necessary to change the make-up of the agricultural lands and increase the production of forage (including perennial grasses) in crop rotations. On the collective farms in the Lake Peipus area market gardening has developed, in particular, the cultivation of onions, cucumbers and chicory. The yields of these, owing to skillful agricultural techniques and sufficient labor, are always very high. In view of this valuable experiment it is desirable that the production of vegetables in the open, and also to some extent in enclosed land, should be expanded.

Besides the general measures indicated for the whole subregion, certain others should also be taken in the separate microregions.

Microregion of the Delta of the Ema and Meelva Suursoo Rivers. This microregion covers a total of 360 km.^{2} in the plain of the Lake Peipus area. The altitudes here differ little from the level of Lake Peipus, so that the predominant bog soils are always affected by ground waters, the level of which reaches the soil surface. The agricultural utilization of land here is very slight, and reclamation of the bogs is very difficult because of the impossibility of regulating the water regime. The sod-slightly-podzolic sandy soils occurring in separate islets in the bog are of poor

TABLE 1

Characteristics of agricultural soil microregions of southeastern Estonia

Agricultural soil microregions	Occurrence of soil groups as % of the area of microregions[a]														Total agricultural land as % of area of collective farms	Agricultural land (%)			Area of soils requiring drainage (%)		Area of acid field soils (%)	
	P	P_{D}^{1}	P_{D}^{2}	E	Pg	P_{G}^{T}	K	Kg	G	G^{T}	B^{N}	B^{P}	B^{V}	A		Plowland	Meadow	Pasture	Of total	Complete draining under all agricultural land	pH below 5.5	pH below 5.0
Region of podzolic, podzolic-bog and bog soils (Lake Peipus area) Subregion of sod-podzolic, podzolic-gley, sod-gley and bog soils (Varn'ya-Vyypsu)																						
Delta of the Ema and Meelva Suursoo rivers	—	7.0	—	—	—	—	—	—	0.1	—	64.9	16.9	11.1	—	—	—	—	—	93	93	—	—
Kodavere-Omedu	0.9	16.5	6.8	—	33.1	0.1	0.1	—	27.8	12.1	2.0	—	—	—	87	49	28	28	76	43	82	67
Varn'ya-Vynnu-Mekhikoorma	2.0	7.0	20.4	0.1	37.7	2.7	—	0.8	8.5	3.9	14.2	1.7	0.3	0.7	74	60	28	12	71	47	83	45
Vyypsu-Satserinna	25.7	9.2	7.7	—	22.1	13.8	—	—	0.8	—	8.1	4.9	7.3	0.4	38	61	24	15	57	46	98	87
Region of sod-podzolic soils (southern Estonia) Subregion of sod-medium-podzolic and strongly podzolic soils (Pyl'va-Ryapina)																						
Akh'ya-Pyl'va-Ryapina	6.5	8.7	52.1	0.8	12.0	2.2	0.05	0.05	2.5	1.5	7.2	2.8	2.8	0.8	68	70	17	13	32	20	95	81
Obinitsa	18.8	23.3	20.9	1.8	24.9	1.6	0.2	—	2.4	1.3	2.2	0.3	0.7	1.6	63	70	13	17	35	9	97	85
Orava	4.2	13.4	30.6	—	40.2	1.3	—	—	2.7	0.3	2.3	0.3	0.3	4.4	71	69	16	15	52	12	100	98
Tsolgo	3.9	1.6	35.0	0.3	28.8	3.3	—	—	4.1	3.0	6.2	6.5	6.1	0.2	62	64	26	10	58	50	100	68
Lasva-Lepassaare	6.2	21.9	18.4	3.2	13.8	2.9	0.1	—	8.6	4.2	14.4	5.4	0.8	0.1	74	62	26	12	50	36	78	56
Subregion of sod-slightly-podzolic soils (Tartu-Vil'yandi)																						
Tartu-Vara	0.1	54.3	3.5	—	17.1	—	1.4	—	7.8	2.7	13.1	—	—	—	84	62	24	14	41	23	51	20
Alatskivi-Pala	1.5	35.5	12.8	—	24.4	1.8	0.2	—	7.5	3.5	10.8	1.5	0.1	0.4	78	61	26	13	50	28	80	56
Region of sod-carbonate leached and podzolized soils (central Estonia) Subregion of sod-carbonate leached, podzolized and sod-gley saturated soils (Pyl'tsama-Iygeva)																						
Saad''yarve-Vazula	0.4	19.8	1.5	—	0.9	—	42.1	0.5	5.3	—	29.5	—	—	—	75	58	24	18	36	35	22	3
Laeva-Il'matsalu	—	—	—	—	—	—	18.9	47.8	16.2	—	17.1	—	—	—	84	53	30	17	81	23	7	0.2
Region of sod-podzolic eroded soils (of morainic hillocks)																						
Loosi-Meremyaye and Liyva-Kanepi	— 15.3	46.2	10.0	5.3	3.8	0.1	1.0	—	5.6	1.2	9.4	0.7	1.4	—	67	68	20	12	22	18	83	61

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[a] P—typical-podzolic soils, PD¹—sod slightly-podzolic soils, PD²— sod medium-podzolic and strongly podzolic soils, E—sod-podzolic eroded soils, Pg—sod-podzolic gleyey and gley soils, PG^{T}—peaty podzolic-gley soils, K—sod-carbonate leached and podzolized soils, Kg—sod-gleyey leached and podzolized soils, G—sod-gley soils, G^{T}—peaty sod-gley soils, B^{N}—humus-peaty soils of lowland bogs, B^{P}—peaty soils of transitional bogs. B^{V}—peaty

rtility and therefore best suited for afforestaon.

Kodavere-Omedu Microregion. Here sod-gley d sod-podzolic-gleyey sands and sandy-loams edominate, it is best to preserve the existing ttern of agricultural land-use, but it is essenal to pay attention to the improvement of the lf-bog meadows and pastures. As peat suitable r compost and litter does not occur here, it ll be necessary to meet the soil's organic maure requirements by farmyard manure (under nditions of intensive livestock) and by growing een manures. In order to introduce sweet clor (*Melilotus alba*) as high quality green maure the acid soils must be limed. The meadow nds require hardly any liming as many sodey soils are fully saturated with lime.

Varn'ya-Vynnu-Mekhikoorma Microregion. In is area sod-podzolic-gleyey sandy loam and nds and sod medium-podzolic sandy-loams preminate, requiring liming both in fields and in eadow-pastures. In order to increase the nount of organic manure it is good to use peat om lowland and transitional bogs both in comost and for litter. To develop intensive liveock it is necessary to increase the area of stures and to some extent of meadows at the pense of arable land. In field rotations the roduction of perennial grasses and flax should increased at the expense of cereals and potaes, as the yields of the latter are low, owing to cessive moisture in the autumn.

Vyypsu-Satserinna Microregion. Here there is ery little land reclaimed for agriculture, and pically-podzolic, peat-podzolic-gley and sododzolic-gley sandy soils, distinguished by low rtility, predominate. There is no question of creasing soil reclamation for agriculture. Some f the low-fertility sands should be afforested. he prospects for the development of livestock re extremely slight, so that attention should be oncentrated on developing the production of ax, potatoes, and, in places, vegetables. In order to increase the fertility of sandy soils, perenial lupine should be introduced; our experients show that this gives about 30 metric tons f green matter per hectare on sand in the first ear of cultivation.

Region of Sod-Podzolic Soils

This region constitutes 53% of the area under onsideration. The original rocks are Mesodevonic deposits (sandstone with layers of plastic clay), covered with a thick stratum of ground moraine. The relief is flat with undulations, broken up by ancient valleys. These deep, narrow, erosion-type valleys, formed in Late-Glacial or Post-Glacial times, are of great importance in regulating the flow of thawing spring and ground waters. Thus, half-bog soils in this region are comparatively few, and gley and bog meadow soils are generally widespread in the ancient valleys.

The soil-forming rock is mainly reddish-brown bouldery moraine, whose carbonate nature diminishes sharply from north to south. Associated with the varying carbonate content of the moraine is the fact that its surface layers are leached to varying degrees. Sod-podzolic soils in various degrees of podzolization predominate in the region. The majority of them require liming and the application of organic matter.

The agricultural utilization of the region is comparatively high (see Table). Great areas are occupied by fields. These result in a scarcity of grasslands for hay and, particularly, of pasture. Changing this proportion is one of the important organizational measures for developing livestock. In view of the ample area of bogs it is easy to use peat for litter and composting.

This region is subdivided, according to the prevailing soils, into two subregions.

Subregion of Sod Medium-Podzolic and Strongly-Podzolic Soils. The soil-forming rocks—carbonate-free sandy clay loams and sandy loams, and, in places, under forest and along ancient valleys—are morainic sands. Owing to the presence of the carbonate-free moraine the process of podzol-formation is strongly developed here. Sod-medium-podzolic and strongly-podzolic soils predominate. Soils overlying parent material differing in texture of their layers (double-layered) are widespread. These soils have an unfavorable water-air regime. Although a temporary excess of moisture occurs very seldom in these soils (in gleyey soils there is generally not much), selective drainage would nevertheless considerably improve the aeration and heat regime.

As the existing area under forage crops does not ensure a sufficient amount of forage (particularly during summer), a fundamental change in the pattern of agricutlural land use is necessary. It is desirable to increase the area of cultivated perennial pastures at the expense of arable land and to increase the proportion of perennial grasses in crop rotations. Liming of all reclaimed soils is necessary for this. In order to create cultivated meadows in the ancient valleys, complete drainage of gley and lowland-boggy soils is necessary. In addition to these general improvements, special measures need to be taken in the separate microregions.

Akh'ya-Pyl'va-Ryapina Microregion. Here sod medium-podzolic and strongly-podzolic very acid sandy loams and silty sandy loams overlying carbonate-free clay loam moraine predominate. Sod strongly-podzolic soils constitute about 12 to 20% of the latter; they show symptoms of slight gleying and occur in the depressions of the microrelief. Besides liming, all the soils require high rates of organic manure. In order to increase the amount of the latter, peat should be utilized as litter. Although it is desirable to increase the area under perennial grasses and other forage plants, it is also necessary to pay great attention to the production of flax, potatoes and small grain. Among the latter, comparatively higher yields are given by oats and winter rye. Soil conditions here are unfavorable for growing alfalfa and sweet clover (*Melilotus alba*), in view of which liming with local shale ash is necessary. Local experiments in livestock show that, besides raising large cattle, raising swine is very important.

Obinitsa Microregion. In addition to sod medium-podzolic sandy-loams, sod medium slightly-podzolic and typical-podzolic sandy soils occur in this area. Soils suitable for increasing agricultural land are scarce. Some of the low-fertility sands should be afforested. In order to enrich the soils with organic matter green manures should be grown—in the first place perennial alfalfa, and, after liming (mainly with local tuff), sweet clover (*Melilotus alba*). The primary task is to alter the pattern of agricultural land use in the direction of increased forage-crop production.

Orava Microregion. Many sod-podzolic gleyey soils overlying double-layered parent material occur here. In addition to soil liming, draining of sod-podzolic gleyey soils, partly by complete drainage and partly by a selective network and open trenches, is of great importance in changing the pattern of agricultural land use and the introduction of green manures.

Tsolgo Microregion. Large areas of sod-po
zolic gley, sod gley unsaturated and bog so
occur here. Their fundamental improvement
the primary agricultural task. It would be pos
ble to grow grass for hay on these soils. Ho
ever, the area of pasture should be increase
even at the expense of arable land, in order
develop intensive livestock in the microregio
As there are many small lakes, the breeding
water fowl would be appropriate.

Both the arable and meadow-pasture so
need liming. Peat from lowland bogs can be us
as compost material, and from transitional ar
upland bogs both for compost and for litter.

Lasva-Lepassaare Microregion. The first tas
in this microregion is the draining of the hal
bog clay and bog soils, but the fields must als
be made over to perennial cultivated pasture
Strongly acid, arable soils first and foremost r
quire liming. Slightly acid arable and meado
soils are generally saturated in the deeper h
rizons. Timely cultivation of soils is also of grea
importance, as on clays a sharp drop in yields
field crops is observed as a consequence of i
correct cultivation.

Subregion of Sod Slightly-Podzolic Soil
The most fertile sod slightly-podzolic coarse cla
loams in southeastern Estonia predominate her
The agricultural utilization of the subregion
at a comparatively high level. The area of agr
cultural land could, however, be increased b
reclaiming the peaty soils of lowland bogs. Th
solution of this problem is important for in
creasing the area of grassland for hay. For th
creation of perennial cultivated pastures it wi
be necessary to a certain defined degree to de
crease the proportion of fields under crops.
the sphere of agricultural technique, corre
methods and well-planned manuring of all crop
play an important part. Also important is in
creasing the organic matter content in the so
by means of peat compost and green manure.

Tartu-Vara Microregion. Sod slightly-podzol
soils are formed here over carbonate morain
clay loams, and their surface horizons have
slightly acid or even neutral reaction. Limin
must be of a selective type and must be carrie
out according to the data of the detailed so
acidity maps. Alfalfa and sweet clover (*Melil
tus alba*) are grown successfully on many farm
even without special measures being taken. Th
possibility of growing these valuable crops in

eases considerably following the liming of ghtly acid soils. In this suburban microregion e thorough development of all branches of in-nsive animal and crop production is very de-able.

Alatskivi-Pala Microregion. This microregion distinguished by the fact that the soil-forming rent materials are noticeably poor in carbon-es. Sod-podzolic soils have therefore an acid ven strongly acid) reaction and require liming. ming is also essential on the small areas of eadow-pasture. The area of excessively wet ils here which are suitable for producing mead-vs and pastures after draining is somewhat eater than in the Tartu-Vara microregion.

Region of Sod-Carbonate Leached and Podzolized Soils of Central Estonia

The subregion of sod-carbonate leached, pod-lized and sod-gley saturated soils occupies 9.2% the area studied and is found in the north-estern and western parts of the Tartu region. he soil-forming parent materials here are grey-n-brown and yellowish-brown bouldery clay am carbonate moraines. Therefore, soils with neutral reaction predominate here; they can used for the growing of crops sensitive to soil idity. The percentage of land used for agri-lture in this area is comparatively high and n be raised still further by draining and re-aiming strongly half-bog and bog soils. The ttern of agricultural land use is also satis-ctory, so that all the conditions for thorough ricultural development are present.

Saad"yarve-Vazula Microregion. The relief nsists of ridges and drumlins; drumlins made p of carbonate moraine alternate with half-bog wlands. Sod-carbonate podzolized (and also ached) and sod slightly-podzolic sandy loam nd coarse clay loams overlying the drumlins are rtile, have a good water-holding capacity and e distinguished by their drought-resistance. rosion on the drumlins is not great, owing to e structural properties of the carbonate mo-ine. The soils are suitable for all crops; al-lfa and sweet clover (*Melilotus alba*) should introduced first. Correct agricultural tech-ques and careful attention to the young grow-g crops secure fairly high yields of all crops, the experiments of the leading collective rms "Avangard" and "Tulevik" show. Bogs in lleys between drumlins are suitable, after draining, for putting down to cultivated meadow. Peat from these bogs can be used for preparing various composts.

Laeva-Il'matsalu Microregion. The relief is almost level, with some sloping morainic ridges and hillocks. The soil-forming carbonate morainic clay loams of fine texture are of poor water-permeability and the surface waters stagnate on them. Sod-gley leached and sod-gley saturated clay loams are very widespread here; they require regulation of their water-air regime, after which they are found to be very suitable for cultivated pastures and meadows and for various forage plants. Large-scale cattle breeding is the chief line of agriculture in this microregion, as small grain (apart from winter wheat) and potatoes have proved difficult to grow here.

Region of Sod-Podzolic Eroded Soils

This region occupies only 3.8% of the area described on the edges of the Otepya-Khaan'ya elevation. The relief is undulating-morainic; the domal morainic hillocks which predominate here alternate with half-bog narrow depressions and hollows. The soil-forming parent materials are morainic bouldery sandy loams and sands around Liyva-Kanepi and morainic clay loams and sandy loams of varying carbonate-content around Meremyaye-Loosi. The soils are subject to erosion, but to a lesser extent than in other parts of the region which lie outside the area described. However, on the steep slopes of the plowed hillocks the soil horizons are eroded in many cases.

In order to check erosion and to increase soil fertility, the area under sown perennial grasses must be extended and long-term cultivated pastures established, especially on the soils of medium and fine texture. Eroded sands must be afforested. The cultivation and manuring of the soils of this region are dealt with in greater detail in Kask's paper (2) describing water erosion and its control in Estonia.

Conclusion

A specific classification scheme for delineating agricultural soil regions, based on general natural, geographical and soil conditions, is proposed. Particular attention has been paid to the finer classification schemes described, as exemplified in the agricultural soil regions of southeastern Estonia.

The agricultural soil microregion must be one of the bases, even within fairly small administrative divisions, for the distribution of agricultural undertakings, their specialization and development. The isolation of these microregions must be based on scientific data of detailed research into soil cover and other natural conditions, and also on long-term agricultural experience and the practical measures associated with it.

In conclusion, we note that detailed economic studies within the defined agricultural soil microregions (and also regions and subregions) are necessary for the more fundamental solution of all agricultural problems. Only a close liaison between the researches of agricultural soil scientists and economists can suffice as a foundation for a full development of agriculture.

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CONTENT OF MOBILE COMPOUNDS IN PODZOLIC SOILS OF THE MOSCOW REGION

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THE process of podzolization, resulting in the formation of podzolic soils with their characteristic profile and properties, occurs under forest cover, especially moss-conifers, in a leaching regime. In spite of numerous investigations, the nature of podzolization has not been sufficiently studied, especially with regard to the movement of iron and aluminum in the soil profile. There are almost no data characterizing the annual cycle of the process or explaining its dependence on weather conditions.

To study podzolization and forest vegetation as related to the soil, the soil science department of Moscow State University established permanent sampling areas on the Zvenigorod biological station in the most abundant forest types in the southern forest zone (11). Determinations were made of leaf fall, the consequent addition of mineral elements, the supply of litter, and changes in chemical properties of the soil during the growing season (Samples were taken 1 to 5 times each month).

This article presents data characterizing the content of soluble compounds in soils under green-moss, spruce and pine forest. The soil under spruce is strongly podzolized coarse clay loam on thin (35 to 40 cm.) coarse silty clay loam, underlain by gravelly coarse sands and unsorted sands. The litter is 3 cm. and the A_2 horizon 35 to 40 cm. thick. The soil under pine is strongly podzolized fine sandy loam on thin gravelly sand loam, underlain by gravelly sand. The litter is 3 cm. and the A_2 horizon 35 to 38 cm. thick.

Conditions in 1955 and 1956 were substantially different. This is especially apparent in the water content of the upper horizons (Fig. 1, A) and in the movement of soluble compounds formed in the profile of the soils investigated.

A deficiency of water in the soil in the latter half of the summer and early fall of 1955 led to considerable drying out of the moss cover, and poor growth of it in the late fall. It also led to an increase in tree litter in the fall, winter and spring of 1956: under spruce in 1954 the litter amounted to 3157 kg./ha.; in 1955 to 4472 kg./ha., of which about 50% were needles; by June 1 in 1956 there was 3865 kg./ha., of which 3021 kg. were needles.

The litter of moss-conifer forests introduces a small quantity of strong cations into the biological cycle (8, 9). With the needle fall in 1955, about 15 kg. calcium, 3 kg. magnesium, and 25 kg. nitrogen per ha. were added to the soil under spruce forest. An even smaller amount of cations were added with the needle fall under pine forest.

A characteristic of green-moss conifer forests is the slow mineralization of the organic matter in the litter (Fig. 1, B), which for spruce does not exceed 18 to 29% and for pine 17 to 24% of the supply of 30 to 35 T/ha. (10). This leads to the freeing of a small quantity of elements, particularly strong cations. Total analyses of the litter showed that during the period of intensive mineralization—May, June, July—in 1954 the Ca content of the litter on the sampling areas decreased 18 to 25 kg.; Mg, 5 to 9 kg.; and K, 7 to 15 kg. per ha.

A large amount of water-soluble organic substances result from the complex biochemical processes during mineralization of the litter. They have an acid reaction (Table 1) because of the small quantity of free strong cations. The acid solutions from the litter enter the soil profile and react with its mineral portion. In addition, acids are excreted from the active roots of forest plants and from microorganisms which develop in huge numbers in the rhizosphere of the roots. Especially intense acidification occurs in spruce forest, where the main mass of roots is distributed immediately under the litter. Thus, at a depth of 3 to 9 cm. in soils under spruce we always observe a more acid reaction than at the same depth in soils under pine. We also note a high amount of titratable acidity in the soils, especially in the spring and fall, when it is two or three times as high as in the summer. The amounts of titratable acidity are well correlated with contents of soluble organic matter.

From the data it is evident that the soluble organic materials in litter and soils of coniferous

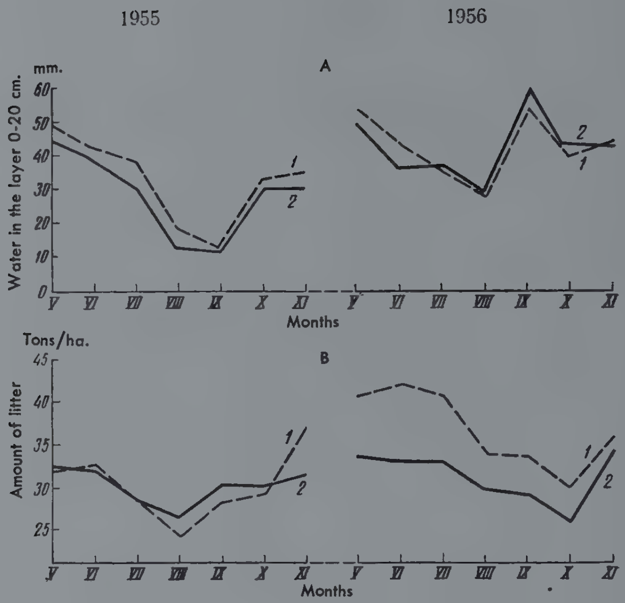

FIG. 1.—A—Water in the layer 0 to 20 cm.; B—amount of litter. 1—Spruce; 2—pine.

TABLE 1

Data from the analyses of water extracts of soils in mg. per 100 gm. of dry soil

Determination	Depth, cm.	1955							1956						
		May	June	July	Aug.	Sept.	Oct.	Nov.	May	June	July	Aug.	Sept.	Oct.	Nov.
Green-moss pine															
Organic matter	0–3	1070	1122	960	1019	880	911	738	1010	788	754	633	612	694	851
	3–9	24	19	11	19	4	29	27	21	14	10	11	41	25	30
	12–20	2	3	9	4	Trace	11	Trace	5	11	6	12	15	12	6
Titratable acidity (in me.)	0–3	2.26	1.99	2.11	2.48	2.04	1.91	1.58	1.88	1.57	1.34	0.92	1.36	1.41	1.43
	3–9	0.08	0.08	0.06	0.08	0.03	0.06	0.08	0.04	0.02	0.02	0.01	0.08	0.06	0.07
	12–20	0.03	0.05	0.04	0.06	0.01	0.04	0.04	0.01	0.02	0.02	0.02	0.01	0.01	0.02
Ca	0–3	Not determined							13.2	11.0	13.3	20.0	6.0	7.9	8.3
	3–9	"							1.3	2.3	1.9	0.4	2.0	1.1	0.9
	12–20	"							1.5	1.6	1.6	0.8	0.5	0.2	0.2
Mg	0–3	"							3.5	2.3	14.0	8.0	2.5	2.7	3.1
	3–9	"							0.1	Trace	0.8	0.8	0.3	Trace	0.2
	12–20	"							0.4	0.3	0.9	0.7	0.2	0.1	0.2
pH of water suspension	0–3	4.66	4.28	5.09	4.39	5.12	5.36	5.29	4.73	4.73	4.70	4.66	4.98	4.88	4.82
	3–9	5.54	5.13	4.88	4.97	4.66	5.15	5.57	5.34	5.18	5.40	5.11	5.13	5.51	5.48
	12–20	5.15	4.64	4.88	4.87	5.15	5.09	5.53	5.43	5.40	5.40	5.40	5.58	5.73	5.81
Green-moss spruce															
Organic matter	0–3	1123	1325	1361	1173	1397	794	583	1175	1258	846	890	1035	996	1155
	3–9	22	38	14	18	16	33	49	41	13	8	19	42	36	38
	12–20	13	10	18	1	4	20	1	25	12	15	2	5	10	6
Titratable acidity (in me.)	0–3	2.23	1.76	2.34	2.77	2.57	1.50	1.49	1.60	2.28	1.51	1.29	1.83	1.63	1.75
	3–9	0.08	0.11	0.12	0.12	0.08	0.10	0.12	0.08	0.04	0.03	0.07	0.13	0.12	0.16
	12–20	0.07	0.06	0.05	0.06	0.02	0.06	0.06	0.02	0.02	0.03	0.01	0.04	0.04	0.04
Ca	0–3	Not determined							19.9	30.8	24.3	27.1	21.9	22.4	22.3
	3–9	"							1.2	0.8	1.6	1.9	2.3	1.4	2.2
	12–20	"							0.6	0.5	1.5	1.2	0.4	0.5	0.4
Mg	0–3	"							8.3	6.6	17.3	12.9	6.8	5.0	7.2
	3–9	"							0.5	0.2	0.7	0.2	0.6	0.8	0.2
	12–20	"							0.3	0.3	0.5	Trace	0.2	0.4	0.4
pH of water suspension	0–3	5.41	6.04	5.75	5.33	4.97	6.13	5.57	5.17	5.10	5.17	5.10	5.42	5.45	5.45
	3–9	4.64	5.15	4.66	4.47	4.39	4.85	4.15	4.63	4.49	4.48	4.48	4.45	4.36	4.35
	12–20	4.64	4.68	4.66	4.98	4.71	4.66	4.66	4.80	4.86	4.64	4.64	4.94	4.58	4.92

TABLE 2

Content of soluble iron and aluminum in soils in mg. per 100 gm. of dry soil[a]

Determination	Depth, cm.	1955							1956							
		May	June	July	Aug.	Sept.	Oct.	Nov.	May	June	July	Aug.	Sept.	Oct.	Nov.
							Green-moss pine									
Fe^{2+}	0–3	18.5	69.6	64.8	24.6	32.7	Trace	18.3	30.1	23.4	45.3	57.1	61.1	17.5	21.2
	3–9	5.5	11.5	14.8	7.0	8.9	7.0	4.9	16.1	19.6	15.8	20.7	35.6	8.3	11.6
	12–20	4.7	11.5	9.0	7.6	8.4	3.5	3.2	10.4	16.0	8.5	20.6	27.2	6.1	9.5
Fe^{3+}	0–3	61.5	6.2	Not detd.	45.6	Not detd.	74.8	54.7	48.3	112.6	64.1	86.1	53.3	82.6	100.3
	3–9	215.0	223.9	"	161.1	"	221.3	202.9	180.1	229.3	272.2	141.6	192.0	203.1	211.1
	12–20	201.4	221.5	"	178.4	"	225.0	210.9	190.8	237.8	274.5	150.4	147.6	198.7	216.9
Al	0–3	110.3	105.1	"	100.8	"	86.5	113.6	96.0	171.5	125.5	107.9	102.4	113.2	129.7
	3–9	136.6	149.1	"	125.7	"	150.9	143.4	151.4	169.1	155.8	120.2	105.4	148.4	142.9
	12–20	147.0	155.4	"	143.0	"	159.1	151.6	151.2	182.8	162.2	127.8	123.8	145.4	140.3
Organic matter	0–3	1164	1173	1199	1179	1300	1138	1262	1611	1401	1253	791	910	1195	1104
	3–9	143	242	142	106	139	88	168	253	210	190	179	230	220	202
	12–20	79	160	106	94	82	63	99	157	177	130	118	112	124	156
							Green-moss spruce									
Fe^{2+}	0–3	26.5	54.8	59.2	22.2	29.3	6.7	20.8	33.5	23.9	39.0	81.9	58.8	12.3	34.1
	3–9	5.5	12.9	13.1	8.0	8.1	15.4	7.9	11.1	19.0	20.9	26.6	35.0	2.8	13.0
	12–20	4.9	12.8	11.0	8.4	6.5	7.4	4.4	12.0	17.8	20.7	18.9	23.1	5.8	8.6
Fe^{3+}	0–3	95.4	67.7	Not detd.	77.7	Not detd.	95.4	92.7	77.2	105.5	118.6	108.9	36.9	94.5	60.0
	3–9	242.5	256.5	"	243.3	"	265.4	279.9	222.8	294.5	319.3	187.1	242.7	232.4	263.3
	12–20	223.8	258.4	"	211.7	"	241.7	261.2	205.8	289.3	325.4	186.3	231.9	242.4	261.9
Al	0–3	111.7	123.9	"	93.6	"	129.5	130.6	121.5	148.8	132.0	98.4	96.7	111.6	91.9
	3–9	136.1	157.3	"	150.1	"	178.0	167.8	111.3	189.7	162.9	109.4	124.2	153.5	128.5
	12–20	143.5	175.5	"	163.5	"	176.0	151.7	175.2	200.3	158.8	141.3	143.3	172.9	164.2
Organic matter	0–3	1301	1507	1559	1351	1521	920	763	1869	1887	1687	1065	1333	1280	1485
	3–9	164	224	174	178	188	1119	167	290	292	258	254	226	278	300
	12–20	126	151	102	118	84	73	79	187	205	144	156	143	161	203

[a] Fe^{2+} was determined with α,α'-dipyridyl; the sum of Fe^{2+} and Fe^{3+} with the sulfosalicylic acid; Al by the acidimetric method; organic matter by oxidation with $K_2Cr_2O_7$.

orests consist mainly of free acids, a small quantity of Ca and Mg fulvates, and possibly of complex compounds with weak cations. For determining the latter a 1 *N* sulfuric acid solution was used (2); in the extract Fe^{2+}, Fe^{3+}, Al and organic matter were determined (Table 2).

Under coniferous forest, divalent iron is found primarily in the litter, amounting to 50 to 60% of the total soluble iron at some times. In the soil horizons characterized by a high content of soluble iron, divalent iron does not exceed 12 to 15% of the total amount. On the spruce soils, the total content of soluble iron was always 30 to 80 mg. higher than in the pine forest soil. The content of soluble aluminum was 50 to 100 mg. less than that of iron. Significant differences in content of aluminum between spruce and pine forests were not observed.

A definite regularity in contents of soluble iron and aluminum appeared during the growing season. Divalent iron accumulated in largest amounts in the spring-summer period, when the water content of the soil was near or even less than that of late fall. The total content of soluble iron, and also aluminum, was significantly increased in the early summer, substantially decreased in the latter half of the summer, and again increased in the fall. We noticed a decrease in soluble iron in the winter and early spring. The amplitude of variations in soluble iron and aluminum compounds was much greater in moist 1956 than in dry 1955 (Fig. 2).

Recently, much attention has been given to the study of the composition of solutions moving through soils, especially forest soils. Ponomareva (5, 6, 7) showed that in podzols and forest podzolic soils calcium fulvates are very mobile, and aluminum and iron fulvates are mobile. At the same time she established that the movement of iron and aluminum depends on their ratio to soluble organic matter, the reaction of the medium, and on the dilution of the solution. De-

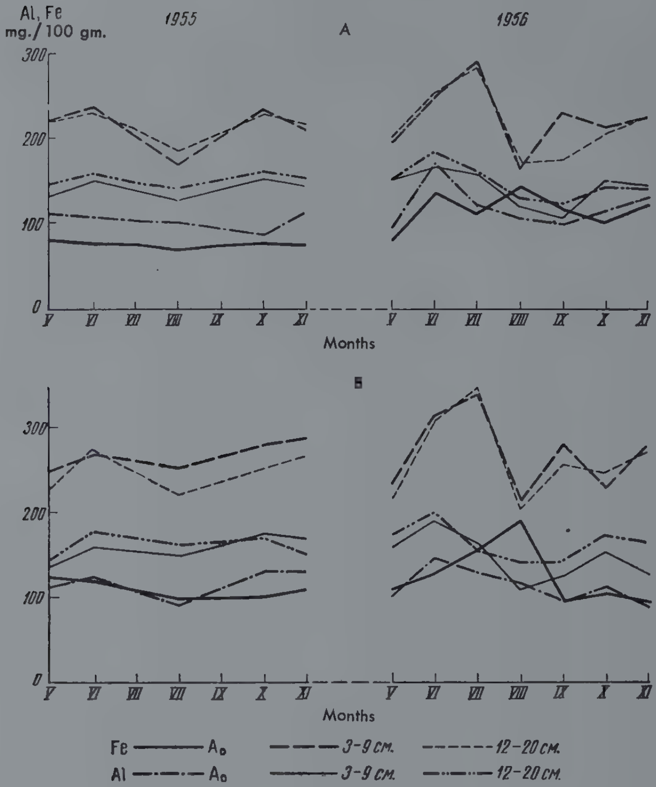

FIG. 2.—Content of soluble forms of iron and aluminum. A—Pine; B—spruce.

Long and Schnitzer (15) came to similar views on the movement of iron in forest soils. Bloomfield (14) showed that water extracts from needles and litter dissolve iron and aluminum, with iron entering the extract in the divalent form. The rate of oxidation of the ferrous complex is insignificant. Moreover, the movement of iron depends on oxidation-reduction conditions created by the seasonal moisture regime (13).

Our experiments showed a tight bond of soluble iron and aluminum with organic matter. In litter, the quantities of water- and acid-soluble organic matter are about the same, but in the soil horizons the content of acid-soluble organic compounds exceeds that of water-soluble by 5, 10, or 20 times, and constitutes 5 to 20% of the total content of humus. Tyurin (12) showed a high content of acid soluble humus in forest soils. We may assume that a large part of the soluble aluminum and iron is combined with acid soluble humus in relatively stable compounds. Their transformation into more or less mobile forms depends on the current biochemical processes. With more intense mineralization of the organic matter in litter, the transformation of slightly mobile into more mobile iron and aluminum increases. In the summer, the decrease in the entry of soluble organic matter into the soil decreases the mobility of organo-mineral complexes, which, with changes in conditions, may again become relatively more mobile. The mobility of organo-iron complexes seems to decrease under the influence of winter negative temperatures. Yet part of the mobile iron and aluminum may migrate in the soil profile in the form of organo-mineral compounds when large quantities of dilute solution enter. For determination of the amount and composition of solutions moving into the soil, lysimeters were installed on the sample areas in 1957.

The changes in contents of soluble compounds in soils help to explain the complex soil formation processes occurring under a cover of green-moss conifer forest. Under the influence of acids developed upon mineralization of litter and excreted from roots and microorganisms, the unique podzolic profile develops, characterized by certain chemical properties. The study of seasonal changes of chemical soil properties explains their annual regularity. The humus content, based on four years of observation, (10), is less than 2 to 2.5% in the spring, decreases 20 to 30% in the summer, and again increases in the fall owing to the entrance and decomposition of water soluble organic matter from the litter (Fig. 3, B). The summer decrease in humus results from its utilization by microorganisms, which at this time have insufficient energy material available. Decomposition of the comparatively ash-free organic material of the litter by microorganisms in the summer releases stronger acid (1). This is reflected not only in the soil reaction, but also leads to an increase in exchange acidity (Fig. 3, A). The use of mineral elements by the forest vegetation in the spring and first half of the summer—during formation of needles, flowers, and new buds—and the increase in H-ion concentration in solution explains the decrease in exchangeable Ca in podzols (Fig. 3, C). Its content increases in the fall and spring as a result of the leaching of mineral elements from the added litter. Analogous regularity appears for exchangeable Mg, K, and NH_4, which are present in smaller quantities in soils under coniferous forest.

The fore-going data confirms that the intensity of podzolization processes under green-moss conifer forests depends on the plant cover, time of addition of litter, character of mineralization of dead organic matter, and interaction of the products of mineralization with mineral parts of the soil under the leaching regime. The most significant changes in the soil take place in the summer and are more intense under spruce than under pine. But the loss of Fe and Al from the upper parts of the soil proceeds mostly in the spring and fall as a result of infiltration of much precipitation and a decrease in concentration of percolating solution. Iron migrates mainly in the form of highly dispersed organic complexes of divalent iron, formed by acidification.

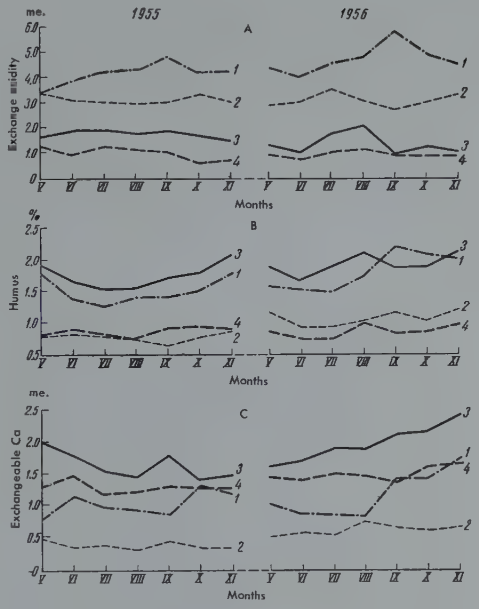

FIG. 3.—A—Exchange acidity; B—humus; C—exchangeable Ca. 1—3 to 9 cm. in spruce soil; 2—12 to 20 cm. in spruce soil; 3—3 to 9 cm. in pine soil; 4—12 to 20 cm. in pine soil.

The intensity of podzolization processes also depends on weather conditions. In wet growing seasons formation of acid organic compounds increases, content of soluble iron and aluminum compounds increases, and their migration in the upper part of the profile is more intensive than in dry years. In growing seasons with little precipitation, there is less accumulation of humus and exchangeable cations in the soil than in years with much precipitation. We must point out that the intensity of podzolization depends not only on the weather conditions of the current year, but on features of the preceding year, which laid the foundation for the succeeding complex biochemical processes (time of addition of its mass of litter, accumulation of humus in the soil, and so forth).

More complete knowledge of the complex soil formation processes occurring under green-moss conifer forests allows the planning of effective measures in forest economy.

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CONTENT AND METHODS OF DETERMINATION OF SOLUBLE BORON IN SOILS

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As with every other element, the total boron content of a soil seldom indicates its fertility with regard to that element. From the agronomic viewpoint, the greatest interest is not in the total content of boron, but in the soluble portion, which is available to plants.

In the literature there are still no adequate workable methods for the determination of soluble (plant available) boron in soils. Individual investigators use different solvents for this purpose and generally obtain non-comparable results.

We studied the solubility of boron in soils with different solvents, comparing the data with results from the plants themselves. The solubility of soil boron was determined in water and weak solutions of hydrochloric acid as affected by time of reaction and temperature of the solution. The investigations were carried out with the plow layer of a fine clay loam wooded podzol of the Dolgoprudny agricultural chemistry experiment station of the Scientific Institute for Fertilizers, Insecticides, and Fungicides, and several other soils.

To investigate the significance of reaction time for the solubility of soil boron, the boron content in a cold water extract (room temperature) obtained after shaking the soil with water for one hour was compared with that in an extract obtained after shaking the soil with water for five minutes and allowing it to stand one day. The reaction time was one hour or 24 hours with the same ratio of soil to water (1:2). The test was repeated with hot water. Soil was boiled with water at the same ratio (1:2) for 5, 10, 20, or 30 minutes, using a reflux condenser. Boron was determined by the colorimetric method of Berger and Truog (with quinalizarin). The results are shown in Table 1.

We found that the amount of soluble boron increases by one half with an increase in reaction time from one to 24 hours using cold water. The solubility of boron in hot water is several times greater than in cold. However, increasing the time of reaction of hot water with the soil from 5 to 30 minutes causes very little increase in the solubility of soil boron. Therefore, there is no need for long reaction of boiling water with soil in using hot water extracts for determining soluble boron in wooded podzols. The extraction of boron with hot water proceeds in the first 5 to 10 minutes, and longer boiling does not increase the amount of soluble boron appreciably.

Determinations of the solubility of soil boron in hot water were also made using several successive treatments of the same sample of soil. Following treatment the liquid was filtered off and its boron content determined; the soil and filter paper were again treated with hot water, keeping the same ratio of soil and water. The results of analyses for boron content in extracts obtained in this way are given in Table 2 where it is seen that the second treatment of the soil with hot water gives much less boron in the extract (4 to 5 times) while the third and fourth treatments show further significant reductions in the water soluble boron content of the soil.

In reported methods of determining water-soluble boron in soils, distillation of boron with methyl alcohol as methyl borate ester is recommended. This operation is quite laborious and greatly complicates the analysis but we were interested in the possibility of determining boron in the water extract without distillation. In every case identical values were obtained; the slight discrepancies in the values are within experimental error (Table 3). No difficulties arose in the analysis as a result of eliminating the distillation of boron with methyl alcohol and similar results were obtained with a number of other soil samples. On the basis of these data we determined water soluble boron in soils, as a rule, without distilling it with methyl alcohol.

To investigate the effect of temperature and concentration of acid on the solubility of soil boron, the following experiments were conducted: a) soil (clay loam wooded podzol, Dolgoprudny) was shaken one hour at room tem-

TABLE 1

Effect of reaction time of water with soil on solubility of boron in clay loam wooded podzol

Solvent	Reaction time of water with soil	Content of water soluble boron in mg./kg. of soil
Cold water, shaking	1 hr.	0.11
" " standing	24 hrs.	0.17
Hot water, boiling	5 min.	0.40
" " "	10 "	0.42
" " "	20 "	0.43
" " "	30 "	0.45

TABLE 2

Extraction of water soluble boron from soils upon repeated treatments with hot water (mg./kg. of soil)

Soil	Extraction			
	First	Second	Third	Fourth
Clay loam wooded podzol (Dolgoprudny, Moscow district)	0.42	0.08	0.03	0.01
Sandy loam wooded podzol (Lyubertsy, Moscow district)	0.16	0.04	0.01	0.005

TABLE 3

Importance of distillation of boron with methyl alcohol in determination of water soluble boron content in soils

Soil	Boron content, mg./kg.	
	Without distillation	With distillation
Clay loam wooded podzol (Dolgoprudny)	0.42	0.40
Sandy loam wooded podzol (Lyubertsy)	0.16	0.14
Red earth (Anaseuli, Western Georgia)	0.50	0.50

perature with hydrochloric acid of different concentrations (0.01, 0.05, 0.1, 0.5, and 1 N) at a soil to acid ratio of 1:2; b) soil was boiled 20 minutes with hydrochloric acid of different concentrations, using a reflux condenser. The boron content was determined in the extracts obtained. Results of the analyses are shown in Table 4. These data show that less boron is extracted with cold hydrochloric acid than with hot; acid concentration increases from 0.01 to 0.5 the solubility of boron increases, but a furth increase (two-fold) in acid concentration do not affect the solubility of boron. The solubilit of soil boron in hot hydrochloric acid increase insignificantly upon changing the concentratio from 0.01 to 0.1 N.

Besides studying the results of concentratio and temperature of acid, the effect of reactio time of boiling acid with soils on the solubilit of soil boron was also studied. Soil was boile with 0.1 N hydrochloric acid at a ratio of 1:2 using a reflux condenser, for 5, 10, 20, and 3 minutes. Table 5 illustrates that increasing th boiling time of acid with soil from 5 to 30 min utes is accompanied by almost no increase i the amount of soluble boron. All of the boron extracted from clay loam wooded podzols by boiling with 0.1 N hydrochloric acid goes into solution during the first five to ten minutes.

The boron contents in soils of various groups were determined by extracting with several solvents: cold and hot water and hot 0.1 N hydrochloric acid. Eight different soil samples were analyzed. The soils were extracted with cold distilled water by shaking at ordinary room temperature for one hour at a ratio of soil and water equal to 1:2, and with hot water, at the same ratio of soil and water, by boiling for 15 minutes using a reflux condenser. Hot acid extraction was carried out under the same conditions as hot water extraction.

The analytical data in Table 6 shows that the lowest contents of soluble boron are found in the sandy loam wooded podzol from the Lyubertsy experimental field and in the Chakva red earth. Others in increasing order are: clay loam wooded podzol, gray forest soil, sierozem and all samples of chernozems. The least amount of boron was extracted from the soils with cold water while hot water extracted a significantly greater amount. Hot 0.1 N hydrochloric acid extracted more boron from soils than hot water, although for the sandy loam wooded podzol the increase was slight, and for the red earth was completely absent. For deep and normal chernozems the increase in solubility of soil boron with acid compared to water amounted to 50%.

Experiments were conducted with plants in order to compare the amounts of boron extracted and results obtained from soils by using the preusly mentioned solvents. Clover, flax, and as were grown on three different soils: sandy m wooded podzol (Lyubertsy), clay loam oded podzol (Dolgoprudny), and deep cherno-m (Grakovo). Clover was grown in glass pots asuring 15 x 20 cm., with a capacity of 3 kg. soil; flax and peas were grown in metal pots, asuring 18 x 20 cm., with a capacity of 5.5 . of soil. To all pots a base application of NPK s added. Since boron was not applied, the pply of this element for the plants came en-ely from the soil. Clover was harvested in the ossom stage, flax and peas at full maturity. he experiments with flax and peas were con-cted for two years. In the second year the soil the pots was broken up, application of NPK s repeated, and the same crop was reseeded. elds of all crops were analyzed for boron ntent.

The data in Table 7, which characterizes the ount of boron available to plants from the il, relates only to the top portions of the yield xcluding roots), and thus appears somewhat duced. The amount of soil boron absorbed by ants seems to depend strongly on the bio-gical properties of the plant and the yield, as ell as on soil properties. Boron absorbed by ants in the first year of the experiment from ndy loam wooded podzol varied between the nits 0.15 to 0.27 mg., from clay loam wooded odzol, 0.11 to 0.34, and from deep chernozem, 21 to 0.50 mg. boron per kg. of soil; in the cond year, for sandy loam, 0.06 (flax), –0.15 eas), for clay loam, 0.12 to 0.20, and for ernozem, 0.21 to 0.43 mg. boron per kg. of soil. e note a great difference in assimilation by flax d pea roots; the latter assimilate soil boron to greater extent than flax.

TABLE 4

Effect of concentration and temperature of HCl on solubility of soil boron in clay loam wooded podzol

Normality of HCl	Boron content of extract, mg./kg. of soil	
	Cold	Hot
0.01	0.18	0.40
0.05	0.31	0.43
0.1	0.32	0.44
0.5	0.48	—
1.0	0.48	—

TABLE 5

Solubility of soil boron with various reaction times of 0.1 N HCl with clay loam wooded podzol

Reaction time with soil (minutes)	Soluble boron content, mg./kg. of soil
5	0.38
10	0.40
20	0.43
30	0.40

TABLE 6

Content of water and acid soluble boron in soils mg./kg. of soil

Soil	Solvent		
	Water		Hot 0.1 N HCl
	Cold	Hot	
Sandy loam wooded podzol (Lyubertsy, Moscow district)	0.13	0.20	0.25
Clay loam wooded podzol (Dolgoprudny, Moscow district)	0.16	0.38	0.50
Clay loam gray forest soil (Simbelevsky experiment station, Gor'kovskoye district)	—	0.45	0.62
Deep chernozem (Grakovo, Khar'kov district)	0.22	1.65	2.50
Ordinary chernozem (Kamenny steppe, Voronezh district)	0.24	1.40	2.00
Calcareous chernozem (Anapa, Krasnodar territory)	0.24	1.75	—
Typical sierozem (Kagan, Uzbek SSR)	0.27	1.70	—
Red earth (Chakva, Western Georgia)	0.12	0.20	0.20

If we compare the amount of boron taken up plants with the results of water and acid tracts (see Table 6), we see that cold water, most cases, extracts less boron from soils than taken up by plants. Thus, cold water extrac-on usually gives low and therefore incorrect dications of availability of soil boron, while xtractions with hot water coincide more closely ith results from plants. The amount of boron oluble in hot water is as a rule somewhat higher, nd in the case of chernozem is considerably igher, than that taken up by plants. This is xplained to some extent by the presence of oron in the plant roots, which we did not consider. For chernozem there is also a considerable supply of available boron, often exceeding the requirements of plants for this element.

TABLE 7
Availability of soil boron to plants (vegetative experiment)

Soil	Plant	Year of experiment	Yield, gm. per pot		Uptake of boron by plants, mg./kg. of soil
			Total	Seed	
Sandy loam wooded podzol	Red clover	1	20.5	—	0.15
	Flax	1	37.7	4.3	0.16
	"	2	20.2	2.2	0.06
	Peas	1	33.1	11.7	0.27
	"	2	29.2	12.2	0.15
Clay loam wooded podzol	Red clover	1	12.3	—	0.11
	Flax	1	58.8	12.0	0.34
	"	2	31.0	5.5	0.12
	Peas	1	37.4	14.7	0.26
	"	2	36.3	14.5	0.20
Deep chernozem	Red clover	1	37.9	—	0.44
	Flax	1	46.6	11.7	0.21
	"	2	32.7	8.1	0.12
	Peas	1	59.0	29.0	0.50
	"	2	60.1	30.2	0.43

All things considered, it may be said that hot water extraction gives a generally satisfactory indication of the availability to plants of soil boron. The use of weak hydrochloric acid extractions for determination of the solubility of soil boron appears to be less expedient.

In conclusion it must be emphasized that the content of available boron in soils is a dependent variable, relying greatly on biological characteristics of the plants themselves, and several other factors. Thus, results with any chemical method will differ from results with plants. Of all reagents studied, hot water extraction gives the most satisfactory indication of availability of soil boron to plants, and is recommended for this purpose.

On the basis of our data, and considering material in the literature on this question, the following method of determining the content of soluble boron in soils is recommended.

Take about 50 gm. of air dry soil. Use a ratio of soil to water of 1:2 (for peat soils, 1:10). Heat to boiling and boil five minutes, using a reflux condenser. The boron is not distilled with methyl alcohol. We recommend determining the boron content of the extract after filtration colorimetrically by the quinalizarin method, which allows the determination of boron with a cision of 1 microgram. The volumetric met of boron determination appears to be consid bly less sensitive[1]. Glass dishes used in the an sis must not contain boron.

Conclusions

1. The amount of boron extracted from a c loam wooded podzol with cold water depends the reaction time of water with the soil. Incr ing the reaction time from 1 to 24 hours creases the amount of soluble boron by one-h

2. Hot water extracts several times more ron from soils than cold water. Upon boiling soil with water the extraction of boron proce in the first 5 to 10 minutes. Increasing the action time of hot water with soil gives alm no increase in the amount of boron in the tracts. Upon repeated treatment of the soil w hot water, the amount of boron going into t extract is sharply reduced (4 to 5 times).

3. Hydrochloric acid in low concentrations a rule extracts more boron from soils than dc water. At the same time, the increase in sol bility of soil boron using hot acid as compar with hot water is relatively small.

4. Comparisons of the solubility of soil bor in cold and hot water and weak hydrochlor acid solutions show that with the amount of b ron taken up from the same soil by plants, t most satisfactory indication of the availab boron content in soils is given by a hot wat extract.

5. The content of water soluble boron (h extraction) in different investigated soils vari between 0.20 (sandy loam wooded podzol a red earth) and 1.75 mg./kg. (chernozem a sierozem).

6. On the basis of the data obtained, a sho description of a recommended method for d termining the soluble boron content in soils presented.

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[1] Detailed descriptions of both methods are give in the book: "Agrochemical Methods of Soil I vestigation," published by the Soil Institute, Aka Nauk, SSSR, 1954, and also in the book: "Metho of Determining Microelements," published by t Institute of Geochemistry and Analytical Chemi try, Akad. Nauk, SSSR, 1950.

HUMUS FORMATION IN IRRIGATED SIEROZEMS OF THE SAMARKAND OASIS

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A study of the organic matter in Central Asian soils was made in one of the oldest irrigated gions, the Samarkand Oasis, which has seen wo or three thousand years of intensive cultivation and irrigation. The purpose of the study as to determine the effect of protracted cultivation and watering on irrigated soils and the ole played by irrigation deposits in the fertility f these soils.[1]

One of the most important factors in the fertility of soils is the presence of organic matter. study of humus forming processes is thus of articular importance in investigating the fertility and genesis of soils. At the present time a reat amount of experimental data has been ompiled, and the main geographic laws have een ascertained which govern not only the accumulation of humus in the soil but also the hanges in its composition in various soil zones 18, 19, 6, 7, etc.).

The next task is to study the processes of umus formation under specific soil and climatic onditions in soils of different groups, in relation o local differences in the conditions of soil formation and to changes in the state of the soil as result of cultivation.

This report contains information on the accumulation of organic matter and humus in virgin sierozems and irrigated sierozems, and on the ualitative composition of the soil humus and he river deposits of the Zeravshan Valley. The oil cover of the region under consideration is made up of normal virgin sierozems and of irrigated soils of various ages formed on the irrigation deposits of the main irrigation canals in the Zeravshan River system: the Dargom, the Karasu and the Bulungur.

In studying the composition and properties of the humus, soil samples were taken from sections typical of the main bodies of cultivated and virgin lands on the right and left banks of the Zeravshan River, and from fluvial deposits (suspended material) that have settled on fields as a result of irrigation. Soils that have been irrigated since antiquity contain a layer of irrigation deposits up to two meters thick. Rozanov (16) has described the morphologic features of the irrigated soils and virgin sierozems. The author merely wishes to note that most of the irrigated soils of the Zeravshan Valley belong to the third drainage terrace of the Zeravshan River and are neither waterlogged nor brackish. They are the chief basis for cotton growing. The virgin soils—ordinary sierozems—lie in the flatlands at the foot of the Zeravshan and Turkestan ridges and their spurs and are partially used under non-irrigated crops.

Vegetation and Root Content in the Soil. The vegetation covering the ordinary non-irrigated sierozems is made up of various mixed-ephemeral desert and steppe grasses: *Poa bulbosa, Hordeum, Psoralea drupacea, Cousinia, Malva, Phlomis bucharica* and others. The yield of the ephemeral group is small, amounting to 0.8 to 1.1 metric tons per hectare; the yield of the ephemeral mixed grass group is 1.5 to 2.0 metric tons of dry weight per hectare. The amount of root material in the virgin sierozems is 8 to 11 tons per hectare, or ten times the quantity of organic matter above the ground (Table 1).

The amounts of root matter in the old irrigated sierozems on which cotton is grown are small in comparison to the virgin sierozems, averaging about 2.4 metric tons per hectare when the cotton plant has reached a fair growth. These figures are somewhat low, since the amount of root material was calculated in July and August when the cotton plants had not yet reached their full growth. Nevertheless they will serve to show that the amount of organic matter added to the soil in irrigated sierozems planted with cotton

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[1] The work was done in the laboratory for the study of the genesis and melioration of the soils of arid and swampy regions, in connection with a continuing investigation of the genetic and agricultural features of irrigated soils in the Zeravshan-Bukhara Oasis. The work was supervised by A. N. Rozanov.

TABLE 1

Accumulations of organic matter in the soil, in tons per hectare of dry weight

Soil	Vegetation	Amount above the surface	Amount of roots[a] in layer from 0 to 60 cm.	Total amount of organic matter
Ordinary sierozem; virgin soil	Ephemeral mixed-grasses	0.8–1.1	8–11.1	8.8–12.2
Old-irrigated sierozem	Cotton plant	Not det'd	1.5–2.5	—
Old-irrigated sierozem	Second-year alfalfa	Not det'd	5.8	—

[a] The amounts of root accumulations in the soil were determined by N.A. Kachinskiy's method for each layer; the determinations were repeated twice. The roots were washed out of blocks 625 cm² in area by elutriation and recovered on a sieve with a diameter opening 0.5 mm.

TABLE 2

Distribution of root masses through the soil profile

Soil	Vegetation	Depth, cm.	Weight of roots, metric tons per hectare	% of total amount of roots in layer
Ordinary sierozem; virgin soil. Section 4	Ephemeral mixed-grasses	0–5	6.61	60.0
		5–10	2.01	18.2
		10–15	0.80	7.3
		15–20	0.65	6.0
		20–30	0.48	4.4
		30–40	0.19	1.8
		40–50	0.18	1.6
		50–60	0.08	0.7
		0–60	11.00	
Old-irrigated meadow sierozem. Section 3	Cotton plants	0–10	1.00	45.1
		10–20	0.88	36.1
		20–30	0.24	9·8
		30–40	0.20	8.2
		40–50	0.10	0.5
		50–60	0.01	0.3
		0–60	2.44	
Old-irrigated sierozem. Section 2.	Second-year alfalfa	0–10	2.13	36.6
		10–20	1.63	28.0
		20–30	0.90	15.4
		30–40	0.46	7.9
		40–50	0.40	6.9
		50–60	0.30	5.2
		0–60	5.76	

is much less than in virgin soils and irrigated soils cropped to alfalfa.

The cultivation of alfalfa facilitates the accumulation of root remains in the soil. In the second year of the alfalfa's growth the quantity of roots in the soil reaches 6 metric tons p hectare, and increases with the age of the alfalf

The distribution of root material in the so profile in ordinary sierozems is typical of ari regions in general (11, 3, 12, etc.).

The largest mass of roots in the sierozem (Table 2) lies in the uppermost layer of the so (0 to 5 cm.) and amounts to 60% of the tot weight of the roots in the soil layer from 0 to 6 cm. The quantity of roots decreases sharply wit the increasing depth, so that the roots betwee the depths of 50 and 60 cm. account for le than 1% of the amount in the layer from 0 to 6 cm.

The distribution of the mass of cotton roots i soil in irrigated sierozems differs from that o the roots of the ephemeral mixed-grasses in virgin soil. These differences are especially sharp i the uppermost soil layer, from 0 to 10 cm. where the quantity of cotton-plant roots is almost eight times less than that of the vegetation growing in the virgin soil. In the 10 to 40 cm soil layer the difference between the amounts of roots of virgin-soil vegetation and cotton plants disappears; below 40 cm., however, the quantity of cotton-plant roots again decreases sharply to almost nothing.

The distribution of alfalfa roots through the soil profile is again somewhat different from that of the roots of the ephemeral-mixed grasses. In the upper layer of the soil the quantity of alfalfa roots is four times less than that of natural vegetation and twice as great as that of the cotton plants. Below the 10 cm. depth the amount of alfalfa roots in the soil greatly exceeds that of the roots in virgin sierozems (by two or three times), and exceeds the quantity of cotton-plant roots in irrigated soils by an even greater degree.

Although the total quantity of alfalfa roots is two times less than that of ephemeral mixed-grasses, the more uniform distribution of the alfalfa roots in the soil profile facilitates soil enrichment with organic residues to a great depth. This is particularly important in increasing the fertility of low-humus soils.

Accumulations of Humus in Soils and Deposits. Many investigators have shown that a characteristic feature of sierozems is their low humus content. The low humus content of the sierozems, in spite of large amounts of plant residues in the soil, is due to the intensive mineralization of the organic substances through the action of microorganisms, which is especially vigorous during the mesothermal phase of development of these soils (6, 9, 16 and others).

The ordinary virgin sierozems of the Samarkand Oasis, like the other sierozem subgroups of Central Asia, are characterized by a low humus content and a rapid decrease in this content as depth increases (Table 3). The greatest amount of humus, which reaches 2.5%, is in the uppermost sod layer. Below the depths of 10 to 15 cm. the quantity of humus decreases sharply, basically following the distribution of root material in the soil.

The irrigated sierozems of the Zeravshan Valley are also low in humus, but the distribution throughout the soil profile is somewhat different from that in the virgin sierozems. Long-continued irrigation of the soil and the cultivation of cotton plants result in a considerable decrease in the organic matter content of the tilled layer of the soil.

The amount of humus in irrigated sierozems also decreases wtih depth, but the humus content in the deeper layers of the irrigated soils as a rule exceeds that of the same layers of virgin sierozems.

A clear idea of the humus distribution in the soil may be obtained from calculations that the author has made of humus accumulations in terms of weight per volume for each layer down to a depth of half a meter. The data in Table 4 show that the total amounts of humus in the virgin sierozems and in continuous-irrigated soils do not differ greatly; the quantity in the 0 to 50 cm. layer is about 70 to 77 metric tons per hectare. In the virgin sierozems, however, the greater part of the humus (up to 54% of the whole) is concentrated in the 0 to 15 cm. layer, whereas the same layer in irrigated sierozems contains only 34 to 35% of the humus. Most of the humus (65%) is in the subsoil at depths from 15 to 50 cm.

These differences in the humus distribution in virgin and irrigated sierozems indicate divergent sources of humus formation and additions of organic residues into the soil. The similarity in the distribution of root matter and humus throughout the profile of the virgin sierozems is evidence that the remains of roots are the chief source of organic matter.

The processes of humus accumulation and formation of a humus profile in the irrigated sierozems are more complex and varied, and are determined not only by the presence of the remains of cultivated plant roots throughout a long period of cultivation, but also by the application of mineral and organic fertilizers (13), by the enrichment of the soil in microscopic plant matter (5), by the annual deposition of clay as a result of irrigation of the fields, and, finally, by the possible filtering down of dissolved organic residues from the upper plowed layer into the subsoil.

TABLE 3

Humus content of soils and deposits

Soil	Vegetation	Depth, cm.	Humus as % of soil (after Tyurin)
Ordinary sierozem; virgin soil. Section 4	Ephemeral mixed-grasses	0–10	2.47
		15–25	0.92
		35–45	0.61
		70–80	0.39
Old-irrigated meadow sierozem. Section 1	Cotton plants	0–10	1.52
		25–35	0.99
		55–65	0.60
		90–100	0.62
Old-irrigated sierozem meadow soil. Section 62	Cotton plants	0–5	1.22
		10–20	1.16
		25–35	0.95
		40–50	0.74
		75–85	0.71
Zeravshan River deposits		suspended matter	0.89
Dargom Canal deposits		suspended matter	0.62

Analysis of the fluvial deposits of the main irrigation canals in the Samarkand Oasis (Table 3) has revealed a noticeable content of humus, up to 0.62 to 0.89%. Since the amount of irrigation deposits that annually settle over the fields as a result of irrigation averages 6 metric tons per hectare (14), the absolute quantity of humus in the annual deposits will be about 50 kilograms per hectare. Thus, continuous irrigation helps to sustain the potential fertility of the irrigated soils because of the presence of a certain quantity of organic matter in the clays of the irrigation water.

Qualitative Composition of the Humus. Table 5 shows the results of analyses of the main groups in the composition of the humus in ordinary virgin sierozems and irrigated sierozems, and the composition of the organic substances in the fluvial deposits involved in soil formation under continuous irrigation.

TABLE 4

Accumulations of humus in the soils of the Samarkand Oasis

Property determined	Depths of layers, cm.							
	0–10	10–15	15–25	25–35	35–50	0–15	15–50	0–50
Ordinary sierozems; virgin soil. Section 4								
Humus as % of soil	2.47	1.50	0.92	0.75	0.61	—	—	—
Bulk density	1.14	1.20	1.20	1.22	1.22	—	—	—
Humus accumulation in layers, metric tons per hectare	28.1	9.0	11.0	9.1	11.2	37.1	31.3	68.4
Humus in layer as % of total humus content of the 0 to 50 cm. layer	—	—	—	—	—	54.2	45.8	100
Old-irrigated meadow sierozem. Section 1								
Humus as % of soil	1.52	1.30	1.25	0.99	0.82	—	—	—
Bulk density	1.19	1.45	1.45	1.45	1.45	—	—	—
Humus accumulation in layer, metric tons per hectare	18.1	8.7	18.1	14.4	17.8	26.8	50.3	77.1
Humus in layer as % of total humus content of the 0 to 50 cm. layer	—	—	—	—	—	34.8	65.2	100
Old-irrigated sierozem meadow soil. Section 62								
Humus as % of soil	1.22	1.16	1.05	0.95	0.74	—	—	—
Bulk density	1.30	1.40	1.45	1.50	1.50	—	—	—
Humus accumulation in layers, metric tons per hectare	15.8	8.1	15.2	14.2	16.5	23.9	45.9	69.8
Humus in layer as % of total humus content of the 0 to 50 cm. layer	—	—	—	—	—	34.2	65.8	100

TABLE 5

Composition of humus in sierozems and fluvial deposits by groups as percentages of total amount of hydrocarbons in the soil

(analysis made by I. V. Tyurin's method)

Section No.	Depth, cm.	Total hydrocarbon as % of soils wt.	Humus (c × 1.72)	Hydrocarbon						
				In alcohol benzene extract	Extracted in decalcification of soil	In humic acids	In fulvic acids	Humic acids / fulvic acids	In "humic" residues of soil	Total
Ordinary sierozems; virgin soil										
4	0–10	1.34	2.31	8.2	8.2	35.1	14.2	2.5	30.6	96.3
56	0–10	1.24	2.14	4.0	5.7	29.5	10.5	2.8	41.1	90.8
63	0–25	0.68	1.17	8.8	7.4	20.6	17.6	1.2	36.8	91.2
Old-irrigated sierozems										
1	0–18	0.89	1.52	5.6	19.1	12.4	16.9	0.7	40.5	94.5
2	0–13	0.73	1.26	6.9	4.1	23.3	12.3	1.9	43.8	90.4
62	0–20	0.71	1.22	4.2	19.7	24.0	12.7	1.9	38.0	98.6
3	0–20	0.49	0.85	6.1	6.1	18.4	10.2	1.8	55.1	95.9
Fluvial deposits										
Zeravshan River		0.52	0.89	6.0	30.5	7.7	9.5	0.8	46.3	100.0
Dargom Canal		0.36	0.62	6.6	30.9	6.1	9.1	0.7	42.3	95.0

A common and characteristic feature of the humus forming process in virgin sierozems and irrigated soils is the relative accumulation of insoluble organic substances in the form of "humin" fractions. This group of substances makes up a large part of the humus (30 to 55% of the total) both in soils formed under dry conditions (virgin sierozems) and in irrigated soils formed under conditions of increased moisture.

Another large part of the humus in virgin sierozems and irrigated soils (30 to 50% of the total humus content) consists of humic and fulvic acids. The remaining part (10 to 25%) is made up of alcohol benzene extracts and of a group of substances separated out in decalcifying the soil. One of the chief components of the humus in the fluvial deposits is also the group of insoluble residues—"humins", which in this case can be as much as 46% of the total humus content. The substances separated out in decalcifying the soil with weak hydrochloric acid, however, do not make up the same quantitative part of the humus content in the fluvial deposits as in the soils. The low content of humic and fulvic acids in the humus of the deposits is particularly noticeable. The substances separated in the extraction of alcohol and benzene are from 4 to 9% of all the soil samples and deposits that have been studied. These are the intermediate products of the dissolution of plant residues and microbic plasmas; they are made up of waxes, resins, fatty acids and certain other organic compounds (21).

The data in Table 5 indicate that the humus forming process under sierozem conditions is very peculiar. In the humus of these soils there is a relative accumulation of slightly volatile organic substances—the so-called "humins", which are securely bound to the mineral part of the soil (17, 20, 4); yet, part of the humus is composed of organic substances that are loosely bound to the mineral part of the soil. These are humic and fulvic acids that are bound mainly to the Ca and to the mobile forms of R_2O_3.

The great accumulation of "humins" confirms the intensity of the process of fixing organic substances in the soil. According to other investigators (10, 15), the "humins" in the humus of the normal sierozems of Tashkent amount to 64%—and in the takyrs to 70 and 85%—of the total humus content.

A typical feature of the humus forming process in ordinary sierozems is thus the intensive fixing of the humus substances in the mineral part of the soil, along with the constant renewal of the soil's humus (Table 6).

TABLE 6

Group composition of the humus in sierozems and fluvial deposits recomputed for "non-humin" soil[a]

Section No.	Vegetation	Depth, cm.	Hydrocarbon				Total of "non-humin" groups
			In alcohol-benzene extract	Extracted in decalcification of soil	In humic acids	In fulvic acids	
Ordinary sierozems; virgin soil							
4	Ephemeral mixed-grasses	0–10	12.5	12.5	53.4	21.6	65.7
56		0–10	8.1	11.4	59.4	21.1	49.7
63		0–20	16.2	13.5	37.9	32.4	54.4
Average of three			12.3	12.5	50.2	25.0	
Old-irrigated sierozems							
1	Cotton plants	0–18	10.4	35.4	22.9	31.2	53.9
2	Alfalfa	0–13	14.7	8.8	50.0	26.5	46.6
62	Cotton plants	0–20	7.0	32.6	39.5	20.9	60.6
3	Cotton plants	0–20	15.0	15.0	45.0	25.0	40.8
Average of four			11.8	23.0	39.4	25.9	
Fluvial deposits							
Zeravshan River			11.1	56.8	14.4	17.6	53.7
Dargom Canal			12.6	58.7	11.5	17.3	52.7
Average of two			11.8	57.7	12.9	17.4	

[a] Total of groups without "humin" represents 100%.

Besides the common features that characterize the humus forming process in irrigated sierozems and non-irrigated ordinary sierozems, certain differences have been noted in the composition of the humus in these soils; these differences are associated with the manner in which the organic substances enter the soil. They involve the more mobile part of the humus and consist of changes in the quantities of certain groups of humus substances.

It can be seen from Table 5 that humic acids make up a great part of the humus in irrigated and non-irrigated soils; their amount is somewhat greater, however, in virgin sierozems than in irrigated soils, ranging from 20 to 35% of the total carbon content. In the irrigated sierozems the amount of humic acids reaches 20 to 24%. The humus in the fluvial deposits is very low in humic acids: only 6 to 7% of the total humus content. The content of fulvic acids is the same under different soil-forming conditions, amounting to about 10 to 17% of the humus both in soils and the deposits that form these soils.

The variations in composition of humus in the soils and deposits under consideration emerge somewhat more clearly when the data are recalculated for the "non-humin" or relatively mobile part of the humus (Table 6). The greatest change in the humus composition of the soils and deposits appears in the humic acids and the substances such as fulvic acids (according to I. V. Tyurin) that are separated out in decalcifying the soil. The humus of the fluvial deposits that make up the irrigated soils is enriched in humic acids as the process of soil formation continues.

Changes in the local conditions of soil formation connected with irrigation of the soil do not seem to have any important effect on humus composition—that is, on the trend of the humus forming process. The humus of virgin sierozems does not in every case appear to contain more humic acids than the humus of irrigated soils. The humus in irrigated soils planted with cotton, for instance, where there is a low intake of organic residues into the soil, contains less humic acid than the humus in virgin sierozems. When the same irrigated soil is planted with alfalfa the humus has almost the same composition as the humus in virgin soils covered with ephemeral-mixed grasses. In view of the limited scope of the data (from one section), it is not possible to draw any general conclusions. It may be supposed, however, that the changes in the biochemical processes that take place in irrigated soils (which have a higher moisture content) are counteracted by the high temperatures and that the humus-forming conditions are close to those of the dry virgin sierozems.

Fractional Composition of the Humic Acids. From the standpoint of soil genesis and agronomy, the greatest interest attaches to the group of humic acids, which are the most typical and active part of the humus and whose presence determines a number of the physical, chemical and biological properties of the soil. The humic acids derived from the soils and deposits of the Zeravshan Valley, as in other soils, are made up of three forms or fractions which are bonded in different ways to the mineral part of the soil.

TABLE 7

Fractional composition of the humic acids (according to I. V. Tyurin's method)

Section No.	Soil	Depth, cm.	% of hydrocarbon in original soil	C in humic acids as % of total C in original soil	C in volatile humic acids		C in humic acids extracted by 0.1 N NaOH after decalcification of soil		C in humic acids extracted by alternately treating with acid and alkali	
					% of total C	% of C in humic acids	% of total C	% of C in humic acids	% of total C	% of C in humic acids
4	Ordinary sierozem; virgin soil	0–10	1.34	35.07	3.73	10.64	26.87	76.62	4.47	12.74
	Same as above	15–25	0.44	13.65	0.66	4.84	8.44	61.83	4.55	33.33
56	Ordinary sierozem developed on old-irrigated soil	0–10	1.24	29.53	2.90	10.00	22.10	76.12	4.03	13.88
2	Old-irrigated sierozem; alfalfa	0–13	0.73	23.29	2.32	9.96	16.86	72.39	4.11	17.64
62	Old-irrigated sierozem meadow soil	0–20	0.71	23.95	1.55	6.47	18.17	75.87	4.23	17.66
3	Same as above	0–20	0.49	18.37	1.12	6.10	13.17	71.69	4.08	22.21
57	Irrigated sierozem; irrigated layer to 60 cm.	0–20	0.64	21.89	1.56	7.14	17.20	78.57	3.13	14.29
	Irrigated sierozem; non-fertilized plot. Control[a]	0–30	0.60	16.7	none	—	9.00	53.89	7.7	46.10
	Irrigated sierozem; fertilized with manure[a]	0–30	0.95	18.2	3.2	17.48	10.9	42.41	7.3	40.10

[a] Data by N. P. Bel'chikova.

The first fraction consists of substances extracted by direct treatment of the soil with 0.1 *N* NaOH, without preliminary removal of the calcium. Acording to studies by I. V. Tyurin, this fraction s made up of brown humic acids found partially n a free state and partially in unstable bonds with Al, Fe and Ca. This is the most mobile orm of humic acid in the composition of the umus. The second humic acid fraction, which s extracted by a 0.1 *N* solution of NaOH from he decalcified soil, is composed chiefly of calium humates. The third fraction is the humic cids derived by alternately treating the soil with 0.1 *N* acid and alkaline solutions; these are bonded to the relatively stable sesquioxides.

The humic acids bonded to calcium predominate in the humus of the sierozems, making up rom 62 to 78% of the total amount of humic cids. Similar data on the fractional composiion of humic acids were obtained by Kostyuhenko (10), who made a qualitative study of umus composition in the normal sierozems of Tashkent, in which the humic acids bonded to alcium amount to 24% of the total humus conent and 90% of the total quantity of humic cids in the composition of the humus. The humic cids bonded to stable sesquioxides in the humus of the Zeravshan Oasis approach 13 to 22% of he total quantity of humic acids.

Regular and persistent differences appear in he content of the mobile humic acids extracted by direct single treatment of the soil with cold .1 *N* alkaline solution, without preliminary dealcification. Although the total content of mobile humic acids in soils of the sierozem type is mall, amounting to only 0.66 to 3.73% of the umus or 6 to 10% of the total quantity of humic cids, the differences in their content indicate ertain peculiarities in the humus forming procss associated with the way in which the organic ubstances are taken into the soil. Thus the reatest accumulation of mobile humic acids (10 to 15% of the total amount in the humus) is ound in the sod layer of virgin sierozems and in rrigated soils that contain fluvial deposits or ave been planted with alfalfa. Smaller accumuations of mobile humic acids (up to 7%) are ound in the irrigated soils planted with cotton nd in the deeper layers of virgin sierozems, where there is a sharp decrease in the quantity f roots that provide the source of the humus.

In spite of the great amounts of energy in the dissolution and mineralization of the organic substances, humus forming processes in sierozems are accompanied by the accumulation of a certain quantity of newly formed (according to M. M. Kononova) substances which are very important in providing and maintaining fertility and changing the physical, chemical and biological properties of the soil.

Conclusions

1. The data on the group and fractional compositions of humus in the soils of the Zeravshan Oasis indicate that the processes of humus formation in irrigated and virgin sierozems are of the same type, the only differences being certain quantitative changes in the content of individual groups of humus substances in the composition of the humus.

2. The humus in the fluvial deposits that are left on the fields as a result of irrigation later undergoes considerable changes in its composition. These changes consist mainly in the enrichment of the humus in humic acids and the decrease in the content of substances extracted from the soil in decalcification.

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DEVELOPMENT OF SOIL EROSION PROCESSES AND THEIR CONTROL IN THE SOUTHERN STEPPE OF UKRAINIAN SSR

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Study of erosion processes and establishment of measures to control them constitute an important problem in the agricultural economy of the Ukraine. The entire steppe area of the Ukrainian SSR has been subjected to the destructive action of wind erosion and violent storms. Much continuous and torrential rain falls over the Ukrainian steppe regions. The parent materials—loess and loess-like clay loams—easily lend themselves to erosion by the action of streams formed from thawed snow and torrential rains. The formation of vertical walls during erosion results in well-developed gully erosion in the Ukrainian steppe (1).

The soils on the "Den' Urozhaya" collective farm of the Berezovskiy district and the "Chervoniy Perekop" collective farm of the Razdel'nyanskiy district of the Odesskaya region represent typical examples of gully erosion. Gully banks on the territory of the "Den' Urozhaya" collective farm are covered by a dense system of deep gullies 150 to 900 m. long. Some gullies are 450 m. wide. Gully areas vary from 1.0 to 12.0 hectares. There were 27 hectares of gullies on the "Chervoniy Perekop" collective farm in 1938, whereas a survey repeated in 1946 revealed 51 hectares of gullies; that is, the gully area increased almost two-fold. The length of gullies increased 50 to 200 m.

Approximately 80% of the land in the steppe regions of the Ukraine is plowed. Improper economic land use has destroyed the soil structure; in several places the arable horizon has turned to dust, which has changed the water regime of the soil. Owing to the small amount of humus, the soil surface easily lends itself to erosion.

We have studied the land relief of ten neighboring collective farms in the Berezovskiy district (comprising 15,000 hectares), four collective farms in the Razdel'nyanskiy district (comprising 9,000 hectares)[1] situated at the northern limit of the southern steppe, and the active work area of the Second Motor Tractor Service and Supply Station of the Odesskaya Suburban district, situated at the extreme south between Khadzhibeyevskiy, Kuyal'nitskiy and Adzhalykskiy estuaries (comprising 30,700 hectares).

The territory of the Berezovskiy district under study is situated on slopes of branching ravines of varying depths. Steep ravine slopes of 3 to 20° are covered by a dense system of gullies. The length of gullies varies from 75 to 1,200 m.; the width varies from 10 to 450 m. Convex slopes are the most common; straight slopes with angles up to 5° are occasionally found, mostly on the arable soils; complex slopes are even more rare.

The erosion level varies from 30 to 115 m. with the smaller figure relating to a small surface area. Although slopes vary from 0.4 to 5.0 km. in length, the long slopes are predominant. The presence of deep erosion levels and long, steep convex-shaped slopes associated with a destroyed soil structure contributes to the intensification of the erosion processes in the area presently under discussion (Fig. 1).

In order to study the relief of the Odesskiy Suburban district, we divided the entire territory into four sections: 1) the left bank of the Khadzhibeyevskiy estuary; 2) the right bank of the Kuyal'nitskiy estuary; 3) the left bank of the Kuyal'nitskiy estuary; and 4) the Black Sea coast between Kuyal'nitskiy and Adzhalykskiy estuaries.

The Odesskiye steppe descends quite steeply toward the main river valleys, especially in the vicinity of their right banks. Almost all rivers and ravines run parallel to the Dnester and Bug Rivers. The deepest valley is the Kuyal'nik, whose escarpments are often more than 50 to 60 m. high.

In the first section the left bank of the estuary and the left banks of the ravines are steep, and are dissected by a dense gully system; the basic shape of the slopes is convex, but there are occasional straight slopes in combination with the convex. The second section is characterized by steeper right banks and fewer gullies than on the left bank of the Khadzhibeyevskiy estuary.

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[1] The number and limits of collective farms in this area have now been changed.

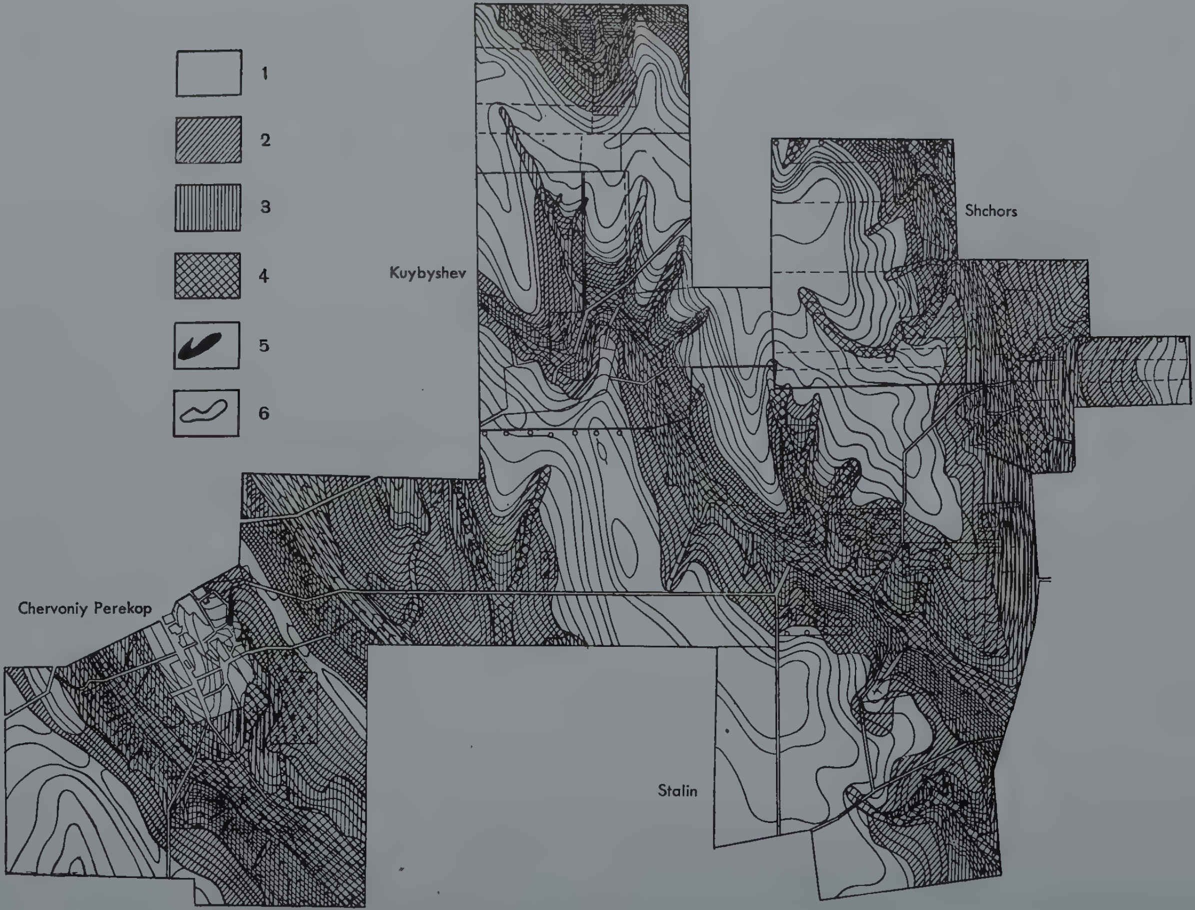

FIG. 1.—A schematic soil erosion map of the collective farms, "Chervoniy Perekop", Stalin, Shchors, and Kuybyshev of the Razdel'nyanskiy district in Odesskaya region. 1. Non-eroded and slightly eroded soils; 2. medium eroded soils; 3. extremely

he ravines are used for pasture land in both of he above sections. In the third section are six mall ravines with eroded bottom and three with roded shore; both banks of the large ravines are overed by a dense system of gullies. In the ourth section are five ravines with eroded bottom and sloping banks. The relief of the plowed nd is flat.

As is obvious from the foregoing characteristics, the local relief in the Odesskiy Suburban district under study contributes to the development f erosion. Gully erosion has been developed to considerable degree.

From vertical survey data for each of the ollective farms in the Razdel'nyanskiy district ve have prepared large-scale hypsometric maps nd legends on the relief and profile of various lopes followed by a general hypsometric map.

The collective farms cover an area of 9,000 ectares. The erosion level varies from 65 to 00 m. with the length of the convex-shaped lopes varying from 0.3 to 3.7 km. The gullies ccupy an area of 54.6 hectares. Data in Table indicates that the relief of the collective farms nder investigation is complex, and typical for rosion landscape.

Soil studies have been conducted in this area y the Soil Science Department of the Odesskiy gricultural Institute (by Assistant L. F. Duov) with students of the agricultural faculty articipating.

Several transverse lines intersecting the basic elief contours have been laid out in the terriory of each collective farm; several basic holes to 2 m. deep) and accumulations (to 1 m. in lepth) have been dug on each line and decribed in detail. Samples of arable and subarale horizons have been taken from soil cores to letermine the humus content and the textures. The following data have been obtained as a reult of field investigations and laboratory analyes.

1. The A and B horizons on the plateau are 00 to 105 cm. thick (depth of the A horizon is 0 to 55 cm.). The color of the humus horizon s dark-gray with a silty granular friable strucure. The depth of effervescence to HCl is 30 to 6 cm. Humus content is 5.2 to 5.8%.

2. The thickness of the A and B horizons on he slopes varies from 0 to 35 cm. depending on he angle of slope and exposure. The color of he humus horizon changes from dark-gray with a chestnut-brown tinge to brownish-gray. The structure is silty granular with a mellow structure. The depth of effervescence to HCl is 0 to 52 cm. Humus content is 1.8 to 5.4%.

TABLE 1

Brief characteristics of relief in the collective farms of the Second Motor Tractor Service and Supply Station of the Odesskiy suburban district

Erosion level, meters	Plowland slopes, degrees	Characteristics of the ravine system			Characteristics of gully	
		Number of ravines	Total distance, km.	Slope, degrees	Distance, m.	Width, m.
65–100	0–4	10	0.8–3.0	15–20	to 750	to 50
40–80	0–4	5	4.5–10.0	to 20	" 500	" 20
40–80	0–4	9	to 3.0	" 10	" 500	" 20
40–80	0–4	10	" 1.0	5–20	500–1400	" 50
"	"	2	above 20	5–20	800–1000	" 50
0–50	0–2	6	0.8–4.0	4–10	200–900	" 15
"	"	2	above 15	" "	" "	" "

TABLE 2

Area distribution in the Razdel'nyanskiy district collective farms by angle of slope

Area in hectares with slope angles, degrees							% of area with slope angles above 2°
0–1	1–2	2–3	3–4	4–5	5–7	Above 7	
2245.8	1562.5	2280.6	1105.9	646.7	651.7	452.2	57.2

3. The soil texture is basically fine clay loam.

The soils under examination are related to the southern chernozem type, a transition to the ordinary chernozem, and characterized by varying degrees of erosion. A schematic soil erosion map has been prepared by plotting soil samples on a large-scale hypsometric map and separating soil according to the degree of erosion. The areas of soil differences have been computed as can be seen from Table 3.

The medium and extremely eroded soils and gullies constitute 45.6% of the total area. The extremely eroded soils and gullies are situated on the slopes of ravines with angles of greater than 5°. Soil erosion continues as a result of the unsystematic livestock grazing. The medium eroded soils border upon the extremely eroded soils by a belt of varying widths dependent upon the degree of slope exposure and economic utilization of the soil.

TABLE 3

Soil area by degree of erosion

Areas	Total area	Category				
		Non-eroded soils	Medium eroded soils	Extremely eroded soils	Alluvia soils	Gullies
Hectares	8940	3817	2115	1878	1053	77
%	100	42.7	23.8	21.0	11.7	0.8

The thickness of the humus horizon on the plateau is used as the criterion for comparison. The collective farms under investigation had been tilled long ago with no unbroken or unplowed soil in the vicinity, although we do not have data available on the size of the genetic horizons of virgin soils for the territory indicated. Proceeding from the data of Kostychev (6) who states that the quantity of humus on the slopes under virgin conditions corresponds to the quantity of humus on the plains, we consider that the reduction of the humus horizon on the slopes of the territory under review is, in comparison with the plateau, basically the result of soil erosion. In dividing the limits of the soils according to the degree of erosion we must take into account, besides the reduction of the humus horizon, the following: the percent of humus, the color of the humus horizon and the depth of the zone of effervescence of HCl.

Soils are termed non-eroded and slightly eroded where less than 12 to 15 cm. of the humus horizon in comparison with the plateau have been removed. They are termed medium eroded soils where 15 to 25 cm. of the humus horizon have been removed; and where more than 25 cm. of the humus horizon have been removed they are termed highly (extremely) eroded soils. The percentage of humus in the non-eroded and slightly eroded soils is 4.5 to 5.8% with the color of the humus horizon grayish-black. The effervescence depth is 30 to 52 cm. The percent humus on the medium eroded soils is 3.0 to 4.5%; the color of the humus horizon is gray with a chestnut-brown tinge. The depth of effervescence is 0 to 30 cm. The predominant slope angles vary between 3 to 5°. The percentage of humus on the extremely eroded soils is 0 to 3%; the color of the humus horizon is brownish-gray or brown with a gray tinge and the humus horizon effervesces at the surface. Wherever the humus horizon has been completely removed, the color the transition horizon is very similar to the colo of parent material. These soils are characterized by predominant slope angles of more than 5 The non-eroded and slightly eroded soils are distributed on the plateau and on slope angles o gradient up to 3°. The alluvial soils are situated on the lower part of the slopes and at the ravine bottoms.

A comparison of the data in Tables 2 and 3 shows that the percentage of medium and extremely eroded soils approximates the percentage of areas with slope angles above 2°. The slopes of the northern exposure are characterized by lesser degree of erosion.

From the results of investigations in the collective farms of the Razdel'nyanskiy district we can conclude that soil erosion has been developed to a considerable degree in the regions of the southern steppe which are characterized by a dissected relief. The control of soil erosion is, therefore, a pressing problem.

Advanced Soviet agriculture has worked out an effective complex of erosion-control measures full application of which would not only remove the causes of erosion formation but would eliminate all its harmful consequences. Among the principal erosion-control measures are: 1) the creation of a system of forest protection plantings, 2) a proper organization of territory, 3) the introduction of regular crop rotation and 4) a rational approach to land use. However, this complex has been adopted to only a small extent.

The methods of carrying out land development in the eroded regions have been published, but only as applicable to the forest steppe zone. The absence of well worked out methods for the various zones leads us to assume that in actual practice errors are committed which are occasionally conducive not to a cessation, but to an intensification of the development of soil erosion processes. Conditions have been created to intensify soil erosion and gully formation by planning to lay the long sides of crop rotation fields and of work strips along the slopes. Forest belts planned perpendicular to contour lines do not control the erosion processes in any way; when laid out at an angle to the contour lines they act in certain zones as moisture accumulators and encourage gully formation (10).

The methods for planning erosion-control easures for the southern steppe of the Ukrainan SSR were applied to the described collective arms of the Razdel'nyanskiy district, considerng the typical complex relief and soil cover.

The "Chervoniy Perekop" was used as the asic planning unit. From 1938 to 1946 the gully rea of the collective farm increased almost wo-fold. The humus horizon on the pasture reas between gullies had been completely roded. An eroded bottom was observed at the avine floor. The area of medium and extremely roded soils totaled 49.8%. No erosion-control easures had been undertaken. The structure f the arable horizon on the slopes had been detroyed, the percentage of humus sharply reuced, and the water regime disrupted. Drought ad begun to be observed more frequently on he fields. Crop rotation introduced in 1947 was ot adopted. Grain crops occupied vast areas ut yields fluctuated and were very low. The nsystematic and irregular livestock grazing is ne of the main reasons for the accelerated deelopment of the erosion on the grazing lands.

In summarizing our experience, the following actors are considered most important in planing an erosion-control organization of the forst steppe territory (2, 3, 4, 5, 7, 8, 9, 11):

1) Establishing a necessary relationship beween classified lands and their proper distribuion according to the elements of relief;

2) Planning regular crop rotation with grasses, ommencing first of all, with soil protecting crop otation on the eroded soils;

3) Planning a system of forest land reclamaion of the whole watershed area;

4) Distributing the limits of fields, work trips, field protection forest belts, roads, alernate grazing fenced areas, and cattle paths on astures, garden and vineyard plots, paying careul attention to relief;

5) Planning ponds for storing surface waters.

Planning in collective farms of Razdel'nyankiy district was carried out in the following rder: We, first of all, studied the natural and conomic conditions of the collective farms. We ext prepared a general plan for the erosionontrol organization of the territory, including he watershed area of the large gully-ravine sysem. We planned only one system of forest proection plantings, ponds, and soil protecting rop rotation for the whole area, keeping in mind the character, shape, and angle of the slopes, the prevalence of eroded soils and eroded gullies.

With the general plan in mind, we undertook various projects for setting up an erosion-control organization of territory for each collective farm.

The most important part of a project—the organization of classified lands and crop rotations—was set up in the following order:

1. Strips destroyed by erosion were divided and earmarked for reforestation.

2. Gully and ravine belts were planned.

3. An inter-farm pond and forest belts around the pond were planned.

4. Based on the schematic soil erosion map, strips of extremely eroded soils were divided up for soil protecting crop rotation and a rotation of cultures on these strips developed.

5. Plans for transforming various classes of land and forage production were drawn up, taking into account the yield of green forage from the area of natural grazing and from soil protecting crop rotation.

6. Forage, field, vegetable and other crop rotation was developed based on the specific structure of sown areas and forage requirements, keeping in mind the need of restoring as quickly as possible the productivity of slightly and medium eroded soils.

7. Crop rotation areas, gardens, vineyards, and other classified lands were allocated.

The complex problem in the internal organization of this territory of crop rotation has been solved in the following manner. Field protection forest belts have been allocated in equal slope portions so that they can contribute to stopping of surface runoff. They are arranged according to the limits of the fields or of the work strips. The crop rotation fields and work strips have a regular profile with sides of reasonable length, while the limits of the fields and strips run parallel to the contour lines or at a minimum angle to them; the field roads follow the shortest route to the production centers. A correct solution of this complex problem becomes more difficult under steppe conditions where the large arable areas call for greater planning than is required for other areas of the country.

The limits of alternating livestock fenced areas and cattle paths on the pastures have been planned so as to run basically parallel to con-

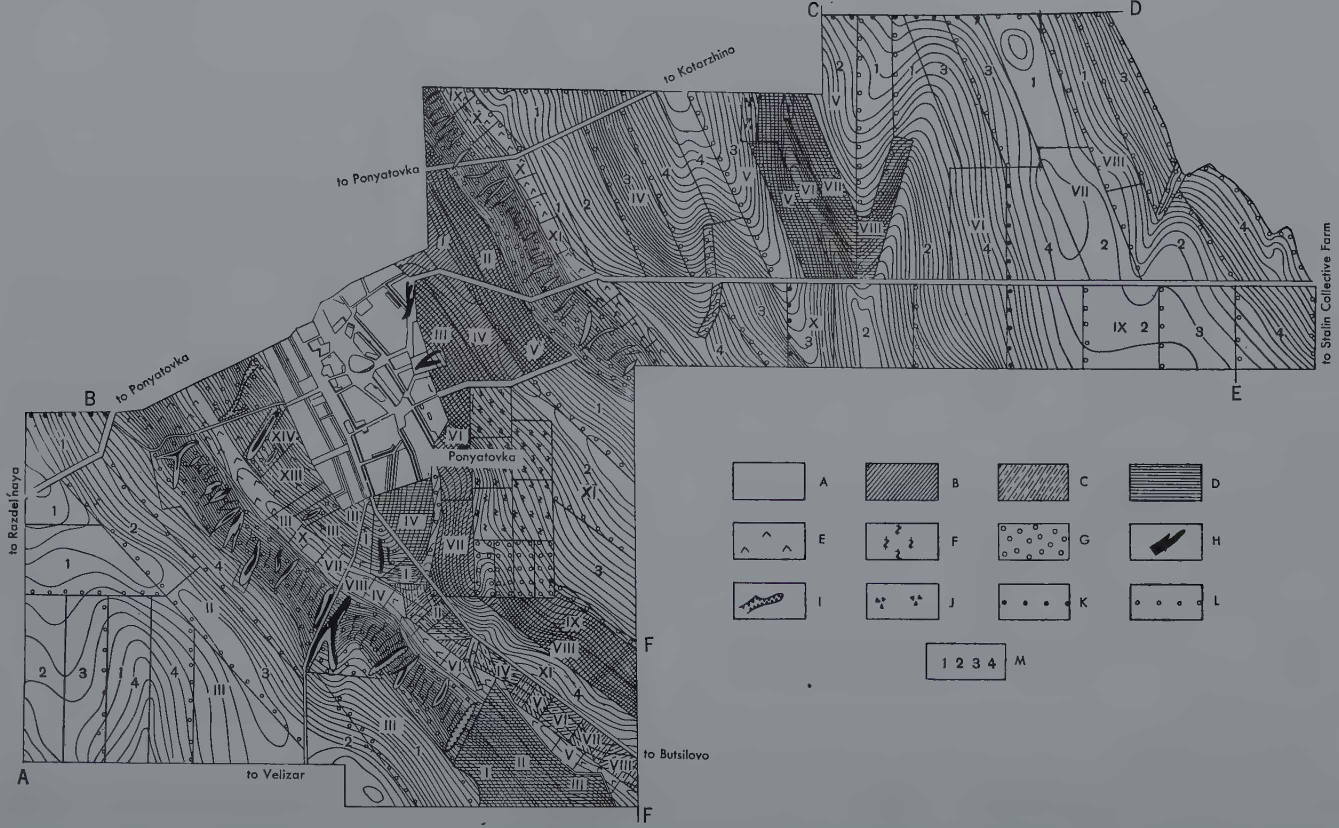

FIG. 2.—Layout of the internal economic land development in the "Chervoniy Perekop" collective farm of the Razdel'nyanskiy district of the Odesskaya region. A—Field crop rotation; B—forage crop rotation; C—vegetable crop rotation; D—soil protection crop rotation; E—pasture; F—vineyard; G—planned garden and mulberry tree; H—gullies of the 1938 survey; I—gullies of the 1947 survey; J—rocky areas; K—present field protection strips; L—planned field protection belts; M—numbers of the work strips of field crop rotati

tour lines. The limits of garden and vineyard plots, as well as limits of crop rotation fields have been planned, taking the relief into account.

We shall illustrate the results of applying the foregoing methods to the "Chervoniy Perekop" collective farm and partly to the Stalin collective farm. The specific changes in the composition and proportion of various classes of lands are indicated by the erosion-control organization on "Chervoniy Perekop" (Fig. 2). The quantity of plowed land is decreased by 4.6%, which is explained by providing for a system of field protection forest belts and by increasing the area of gardens and vineyards. A continuous forestation is planned on the steep slopes of the ravines around the gullies. Gully forest belts are planned on the more steep slopes of the ravines around the gullies, at a considerable distance apart. The total forest area constitutes 12.4%.

The introduction of four crop rotations is anticipated: soil protecting crop rotation covering an area of 185 hectares, common forage crop covering 211 hectares, vegetable crops covering 56 hectares and field crops covering 2,021 hectares. The extremely eroded arable soils and, to some extent, the grazing lands have been set aside for soil protecting crops. Forage crop has been distributed on the medium and extremely eroded soils, while vegetable crop has been established on the low alluvial soils. Field crop rotation has been distributed over the non-, medium-, and slightly-eroded soils. On the Stalin collective farm two forage soil-protecting crop rotations have been planned—the farm crop and the irrigated vegetable and field crop. Since gully erosion on the territory has only been slightly developed, the forestation should amount to 5.9%. The soil protecting crop rotations have been distributed on the extremely eroded soils, of which one rotation protects the pond from silting. The limits of crop fields and of work strips at both collective farms have been planned parallel to the contour lines. At the same time the fields assumed the proper configuration.

The majority of the forest belts in the "Chervoniy Perekop" collective farm (61% of the total length) will be distributed parallel to contour lines and adapted to the limits of the fields and work strips. It has been proposed to set up belts at several places so that they will be at slight angles to the contour lines, to establish the proper configuration of the work strips. The total length of the belts will equal 36%. Therefore, only 3% of the belts will be perpendicular to the contour lines with 3 to 4° angles of slope. (Table 4)

TABLE 4

Distribution of field protection forest belts relative to the relief

Belts	Length of belts, km.	Classification of belts by linear angles of slope expressed in degrees				
		0	0–1	1–2	2–3	3–4
Field crop rotation						
Present	4.9	0.7	3.2	1.0	—	—
Planned	28.0	20.4	5.8	0.9	0.7	0.2
Forage crop rotation						
Planned	2.5	1.3	0.9	—	0.3	—
Soil protecting crop rotation						
Planned	4.4	2.0	1.6	0.8	—	—
Total, km.	39.8	24.4	11.5	2.7	1.0	0.2
%	100	61.0	29.0	7.0	2.5	0.5

Plans have been formulated to space field protection forest belts 200 to 600 m. apart over 75% of the area and 600 to 900 m. apart over the remaining 25%. The mean weighted distance between belts is 488 m. The basic width of forest belts will be 20 m. The first forest belts on medium and extremely eroded soils controlling the water flow from the ravine bluffs will be 25 to 50 m. wide, and the remaining water-controlling belts on the long slopes in the path of water flow will be 20 m. wide.

Considerable importance has been placed on the determination of the economic effectiveness of the measures planned. To evaluate the accepted decision from the point of view of adhering to the main principle of planning crop rotation fields and work strips—the creation of working conditions for motor tractor units across slopes—there have been prepared three sets of figures for the crop rotation area: 1) by degree of slope of the locality—along the line of greatest grade; 2) by degree of slope, surmounted by units proceeding in the direction of work according to our plan; and 3) by the same degree of slope according to the 1947 plan (Table 5). The latter plan differs from ours in that sepa-

TABLE 5

Data of the "Chervoniy Perekop" collective farm crop rotation area

Designation of crop rotation	Area, hectares	Slope classification, degrees					
		0–1	1–2	2–3	3–4	4–5	Above
By degree of slope of the locality (during work along slopes)							
Total plowed land, hectares	2354.2	724.2	359.0	946.0	241.	51.0	33.0
%	100	30.6	15.3	40.3	10.3	2.2	1.3
By degree of slope according to our plan							
Field	2021.3	1724.5	222.1	55.2	14.5	5.0	—
Forage	211.5	193.3	17.3	0.9	—	—	—
Soil protecting crops (less pasture)	121.4	97.1	23.0	1.3	—	—	—
Total, hectares	2354.2	2014.9	262.4	57.4	14.5	5.0	—
%	100	85.6	11.1	2.5	0.6	0.2	—
By degree of slope according to the 1947 plan							
Field	1938.1	1151.4	502.4	180.0	67.0	22.0	15.3
Forage	416.1	128.3	189.7	75.6	18.9	3.6	—
Total, hectares	2354.2	1279.7	692.1	255.6	85.9	25.6	15.3
%	100	54.4	29.4	10.9	3.6	1.1	0.6

ration of soil protecting crop rotation was not foreseen in 1947; instead the long sides of the fields and of the work strips, as well as the field protection forest belts, were arranged basically along the slopes. Pasture area was not organized in the 1947 plan.

By comparing the figures, we see the important advantages to be derived from our plan as opposed to the 1947 plan. The area with angles of slope above 2° in the 1947 plan equalled 16.2% of the total figure and was 5 times greater than the area in our plan having the same degree of slope. Slopes with an angle of gradient greater than 2° along the path of the working units will appear 16.5 times less often in our plan than when work was carried out along the slopes. During work along slopes the area with angles of gradient above 2° amounted to 54% of the total figure.

To determine the economic benefits to be derived from our plan, we made a rough estimate of present annual crop losses on the medium and extremely eroded soils. For computation purposes, we took the data of A. P. Shaposhnikov's investigations of the reduction in the yields of agricultural crops based on one hectare of medium and extremely eroded soils in Dnepropetrovskaya region. Results showed that annual grain losses in the "Chervoniy Perekop" collective farm amounted to 15 to 16,000 centners. Making use of experimental data, the mean percentage of reduction of eroded soil was computed for three crop rotations during field cultivation across the slopes. This reduction in eroded soil amounted to 69% for field crop rotation, 80% for forage crop, and 87% for soil protecting crops.

From all available data, soil erosion on one hectare of medium and extremely eroded soils amounts to, on the average, 7 to 10 tons, while 4 kg. of nitrogen is found in a ton of eroded soil. From this data we see that total nitrogen losses in the collective farm under crop rotation amount to about 36,000 kg. or, converted to grain values, about 12,000 centners. After having applied the computed mean weighted percentages of erosion reduction for the various crop rotations, we derived a decrease in nitrogen losses amounting to 26,700 kg. or, converted to grain values, 8,870 centners by introducing regular crop rotations and by developing fields across slopes. Planting water controlling belts should reduce soil erosion to practically nothing or even remove it altogether.

Conclusions

1. Control of soil erosion is a present-day problem in the steppe regions of the Ukrainian SSR, including the southern steppe regions. A proper organization of territory is the most important prerequisite in the complex of erosion-control measures.

The main features in the erosion-control organization of a territory are: a) the establishment of a proper relationship between different classes of land and crop rotation including their distribution, taking into account the degree of soil erosion and the increase in the percentage of forestation; b) the distribution of the limits of crop rotation fields and of various farm strips across slopes; and c) the proper distribution of forest protection plantings on slopes.

2. To obtain an accurate solution of the problems of each collective farm mentioned previously, we must first set up a general plan for the erosion-control organization of the whole watershed area of the ravine network.

3. We cannot, in the future, carry out land

development in soil erosion areas of collective farms without first having vertical survey and soil investigation data available, since, without this information, we shall commit gross errors which will adversely affect the collective farm economy.

4. It is difficult to overestimate the economic benefits to be derived from the foregoing-planned erosion-control organization of territory when it is fully adopted. Results have shown that soil erosion in the collective farms under study can be decreased 3 to 4 times, thus yielding an increase in productivity as much as 6 to 8 centners per hectare. At the same time a permanent forage crop will be created which will guarantee a considerable increase in animal productivity.

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SOME POPULAR AGRICULTURAL MEASURES FOR EROSION CONTROL IN BULGARIA

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WATER erosion of culivated land is a widespread phenomenon in the People's Republic of Bulgaria. Recent studies show that plowed fields are eroded on land slopes as little as 1.0° to 1.5°. In Bulgaria, 77.2% of the cultivated land or 33.7% of the country's entire territory has this much slope. Destruction and removal of topsoil over such a wide, cultivated area is indeed disastrous to Bulgaria.

The chief reason that erosion causes so much damage is that the fields are located on the slopes of mountains and hills. After the country's conquest by the Turks, land cultivation greatly increased. In the 15th Century, the Turks seized the level areas, and the Bulgarian natives were forced to put new lands under cultivation by cutting down forests and plowing the slopes of hills and mountains. This kind of land utilization continued throughout the entire period of Turkish domination.

After the country was freed from the Turkish yoke (in 1878), cultivation of fields on mountain slopes persisted because, 1) erosion continued to damage the fields, forcing people to cut down stands of trees on steep slopes, and 2) under the newly established capitalistic-bourgeois rule, no one was interested in erosion control measures.

When the people's democratic power was established, after the general revolt of September 9, 1944, conditions in Bulgaria underwent a radical change. One of the country's main problems was to raise its production level, including the level of agriculture. At first it was not clear to what extent erosion decreases and destroys soil fertility. To clarify this question, a Soviet-Bulgarian soil expedition was organized in 1947 under the leadership of I. P. Gerasimov and I. N. Antipov-Karatayev. Their investigations disclosed that the country's cultivated lands were being greatly damaged by erosion.

This problem became especially acute when water reservoirs, newly constructed and under construction, were threatened by silting through erosion products mostly washed in from cultivated fields. To decrease and halt the decline in the fertility of Bulgarian lands and to elim nate the danger to reservoirs, the Minister Council issued a decree on November 26, 1955, o organizing to combat soil erosion in cultivate fields.

This decree recommends "a thorough stud and use of popular experience and scientifi achievements." It further urges people to "in troduce all possible organizational and othe normal measures commonly used in controllin soil erosion on cultivated lands"; of first im portance are "agricultural measures against soi erosion on mountain slopes."

Let us examine some of the methods used b the Bulgarian people to combat soil erosion Among them is the practice of hilling the eart around crops to form trough-shaped furrows We made a study of the popular methods practiced in various sections of the country: in th neighborhoods of Yelena and Loma, in th valleys of the Struma and Arda Rivers (wate sources for the "Studenyi Kolodets" and "Karjali" reservoirs), Iskyr River (water suppl for the "Stalin" reservoir), Topolnitsa Rive (water supply for the "Topolnitsa" reservoir) and others.

The trough method of hilling around cultivated crops is a hand method used with corn potatoes, and so forth. A depression resembling a small trough or crescent is dug in the soil between four plants. This type of hilling is used in cornfields planted over gray forest soils, o 10° slopes near the town of Yelena, where erosion damage is of moderate severity. The troughs fill with water and retain alluvial deposits. These deposits are partly eroded from the walls of the crescent-shaped troughs, and partly brought in by water seepage. The crescents thus counteract erosion by retaining water and silt.

This type of hilling is practiced sporadically, not systematically. This is evident from the way the crescent troughs are scattered over the entire cultivated area. There is a tendency for the furrows to run parallel to the slope. Crescent-shaped grooves are formed because most of

e soil dug out in hilling the four plants is taken
om the widest space in the center. Figure 1
ows the arrangement of rows of corn and the
ough and furrow pattern. It also shows the
osswise and lengthwise ridges between the
oughs and furrows. The troughs are 30 to 40
n. long and 13 to 19 cm. (on the average, 16
n.) deep. Each trough holds 19.2 liters of
ater, or 51.2 liters per 1 square meter of sur-
ce. Considering the water intake capacity of
e soil (gray forest soils absorb about 70 liters
water per 1 square meter of surface dur-
g the first hour), each equare meter retains
ver 70 to 75 liters. The troughs can thus pre-
ent surface seepage caused by precipitation
the rate of 70 to 80 liters per 1 square meter.
recipitation over this amount is a rare oc-
rrence in Bulgaria.

Besides water, the troughs also hold back
diments. In the troughs examined, the sedi-
ent layer was from 2 to 7 cm. thick, averaging
5 cm. The troughs are capable of holding
ck all sediments on the plowed field; thus,
ey prevent the removal of topsoil and a de-
ease in soil fertility.

It should be pointed out that the arrange-
ent of the troughs is not very efficient. First,
e rows of cultivated plants should not be
rallel with the slopes, but horizontal; then,
e long side of the troughs will also be hori-
ntally placed and their waterholding capacity
ill be increased. Secondly, the troughs should
arranged systematically over the entire area,
prevent streaming of water causing ero-
on gullies. In the case illustrated in Figure 1,
reaming erosion was estimated at 22.9 cubic
eters per hectare. Moreover, the concentrated
rce of waterflow may damage the troughs and
stroy their effect.

Trough-shaped hilling of potatoes is not al-
ays used. It is practiced in the fields of Dosney
llage, Salyukov district. This method is not
popular among farmers as furrow hilling,
hich was discovered accidentally in cultivat-
g field crops.

Furrow hilling of field crops is done either
hand or mechanically. Hand hilling is used
steep slopes of 25° to 30°.

The total average capacity of furrows per
uare meter of surface is 62 liters. This means
at if the water held in the furrows does not
w out, all the precipitation is retained (up
62 liters). Considering the waterholding capacity of the soil, the amount will be over 80 liters. This does not actually happen because the furrows are not horizontal: water accumulates in their lowest sections, then breaks through or spills over the rims. Such destruction of furrows creates stream-type erosion, which turns into linear erosion. As a result, the furrows may remain only partly filled. Figure 2A gives the slope profile where the manual method of furrow hilling was used in a potato field. The slope is 33°, the soils are gray forest type, the locality

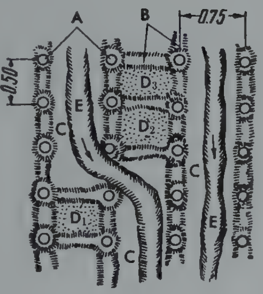

FIG. 1.—Diagram of trough-shaped hilling in a cornfield, in meters. Grencharovo village, Yelena city District. A—cornstalks; B—cross and lengthwise partitions formed in the process of hilling; C—longitudinal furrows running with the slope; D_1, D_2, D_3—troughs with sediment; E—streaming erosion in longitudinal furrows.

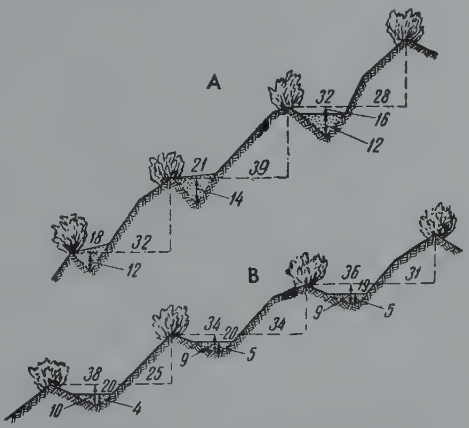

FIG. 2—A—Slope profile showing manual furrow hilling following the horizontal, in a potato field with a 33° slope. Diagram made shortly after silting of furrows. Locality: "Tokat Dere", fields of Svetulka village, Ardinsky district, August, 1955. B—Slope profile showing furrow hilling done with an ordinary moldboard along the horizontal, in a potato field with a 16 to 20° slope. Locality: "Tokat Dere", fields of Svetulka village, Ardinsky district.

is Svetulka village, Ardinsky district; the furrows were filled with sediment from stream-type and surface erosion. In this case, the water seepage was not from the higher parts of the slope because water-deflecting furrows were provided at 7 to 8 meter intervals to carry off the overflow into lateral grooves.

The implements used in making hilled furrows are a common wooden plow, a drill hoe or a ditch plow. The common plow is used for potato plantings in gray forest humus with medium erosion, on 16° to 20° slopes. This is common practice in the fields of Svetulka village, Ardinsky district. Figure 2B gives the slope profile with this type of hilling. It counteracts erosion very effectively. The average depth of furrows is about 10 cm. and the average width of the upper rim is about 36 cm. Average volume content of a running meter of furrow is 36 liters, that of 1 square meter of surface is 54.5 liters. The total capacity of the furrows accommodates the total precipitation, up to 54.5 liters per square meter. With a water capacity of not less than 20 to 25 liters per square meter (since the texture of planting soil is coarser than that of gray forest soils), the total volume of water held will be 75 to 80 liters per square meter. This water retaining capacity eliminates surface flow and is an excellent way to control erosion.

The case described proved the effectiveness of furrow hilling in preventing erosion and sedimentation. Over the entire area where it was used, only 13 small gullies caused by streaming erosion were found, with a total sediment content of 6.4 cubic meters per hectare. Part of the field was left fallow and plowed while the remaining part was hilled. With the same climatic, geo-morphologic and soil conditions existing in both parts of the field, the severity of streaming erosion in the untreated field was 225 cubic meters per hectare, or 35 times more severe than where furrow hills had been dug. Sediments from surface erosion were also retained between the furrows. Sediment retention per running meter of furrow averaged 0.004 cubic meter. For an area of 1 hectare, 60.6 cubic meters or 9.3 the amount of soil was washed in by streaming erosion. Thus, furrow hilling completely eliminates streaming and surface erosion except when water accumulates in the low parts of furrows and overflows. This is one disadvantage of furrow hilling.

Of great interest are comparative data
water, erosion and sediment control by furr
hilling practiced at Gorni Tsibyr, Loma c
trict. Two fields planted to corn, located in
ravine on the left bank of a slope were co
pared. Each field extended from the watersh
to the bottom of the ravine; the average slo
was 6°; the soil was typical chernozem. In c
field, the corn was furrow-hilled in early Ju
the furrows running horizontally. The oth
field was hoed as usual at the same time. C
servations were recorded August 26, 1954.

The pattern of the furrow hills was as f
lows: average width between rows, 75 cm
average width of the upper edge of furrow
50 cm.; average depth, 15 cm. Each squa
meter of surface has a water-retention capaci
of 53.32 liters. The water intake capacity
typical chernozem is over 25 to 30 liters p
square meter. (According to figures of N. Pus
karov Soils Institute it is 124 to 728 liters p
square meter.) The total capacity of water
this case is therefore over 75 to 80 liters p
square meter. If precipitation is not over 75
80 liters per square meter, there is no surfa
runoff. But the furrows could not cope wi
water erosion because they were not correct
arranged: the water overflowed or collecte
on the low ends, spilled and broke the furrow
causing streaming erosion. The volume of wat
was only 11.3 cubic meters per hectare. Neve
theless, it broke the soil surface and leache
out nutrient substances. Deposits of sedimen
washed out of furrow walls, spaces betwee
furrows and, partly from the streaming erosi
on the surface, settled on the bottoms of fu
rows. The total volume of this material was ove
2.80 cubic meters per hectare. Two days be
fore these data were recorded, a rain soake
the ground to a depth of 26 to 36 cm.

In the neighboring field where the corn ha
been hoed in the usual way, severe erosion cause
by streaming was observed: it was over 10
cubic meters per hectare or 9.5 times the volum
eroded in the field where the method of furro
hilling had been used. Here, the roots of plant
were exposed. The rain penetrated to a depth o
15 to 25 cm.—less by a third than in the fiel
where the furrow hills had been dug. Retentio
of drifting sediment was not determined fo
this field.

This comparison shows the indisputable ef
ficacy of furrow hilling along the horizontal

as a method for prevention of erosion and for retention of water and sediments. The practice of both mechanized and manual hilling tends to be sporadic and unsystematic. It is done not always crosswise of the slope but sometimes along with it, and in the latter case, it tends to increase surface runoff and erosion processes.

We can now draw a few conclusions based on popular experience concerning the advantages and disadvantages of trough and furrow methods of erosion control.

We know that both methods are effective, but the effect of troughs is limited because trough-shaped hills cannot be arranged in a regular pattern over the whole area. Ofter they are not constructed over the area and frequently only down to the vertical slope horizontally. On the other hand, furrow hills follow a certain system: they cover the whole field and mostly follow the slope. If they are arranged horizontally, there are no cross ridges made to hold back the flow of water.

We recommend trough hilling in horizontal rows over the entire planting area. This method does not require cross–ridges between each pair of plants, but only between groups of plants. The absence of extra cross–ridges increases retention capacity and decreases labor. The resulting structures are oblong troughs, similar to furrow hills, with cross–ridges in the furrows.

In furrow hilling, the furrows should always run horizontally. On the ends and at intervals along the furrows, cross–ridges are made to hold the water.

There is actually only one effective method of hilling,—the trough–furrow type. The partitions or cross–ridges should be made as far apart as possible, so that the excess water does not collect at one point and break the trough. Water accumulates in this way when the furrows becomes uneven and move out of horizontal line. With the use of mechanized diggers, no breaking or curving was observed in furrows 4 to 5 meters long or longer; or, with hand digging, none in furrows 3 to 4 meters, occasionally less than 3 meters long. For this reason, a distance of 3 to 5 meters is recommended between partitions. Figure 3 is a diagram of trough-furrow hilling.

This study shows that trough furrows can accommodate all the runoff and thus prevent harmful erosion after severe rains or snowstorms (up to 70 to 85 liters per square meter).

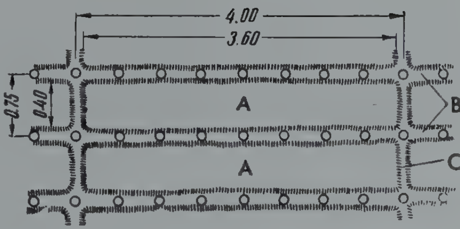

Fig. 3—Diagram of trough furrows. A—trough furrows; B—continuous ridges following the horizontal level; C—cross ridges.

The practice is based on experience and adapts easily to either manual or mechanical hilling methods. It should be manual only when mechanized hilling is impossible, that is, when the terrain slope is over 15 to 20°. Otherwise, trough furrows should be made with farm machinery. The best machine to use on lands with not over 10° slope is the hilling machine (okuchnik); on steeper slopes, a plow. The moldboard of the plow places all the soil away from the furrows, thus increasing their water retention capacity and erosion control.

The cross–ridges along the furrows are made with a hand mattock. One of the problems of agricultural technicians is to construct a special machine for making cross–ridges. For this, the hilling machine must be automatically raised at regular intervals; or there may be another way.

In Bulgaria, erosion in fields planted to crops is observed on slopes of over 1.0 or 1½°. All the fields planted on steeper slopes should be hilled as described, with trough furrows.

As already stated, 77.2% of all the land under cultivation in Bulgaria is built on such slopes. A little less than half of this land is in plowed fields under crops. Trough-furrow hilling operations should be carried out annually over an area covering about two-fifths of the cultivated land or about 1.9 million hectares. Since plowed fields are subject to most damage by erosion, reducing the damage to a minimum over such an immense area would be a great achievement in Bulgarian agriculture.

The benefit of this control measure is further increased because trough furrows retain surface runoff. The resulting increase in soil moisture (by one-third in this case) immediately increases yield.

In addition, trough furrows hold back all the sediments deposited by sheet erosion. This restores soil fertility and increases yield. The retention of sediment by troughs is of great importance in water reservoirs and microreservoirs. Plowed cultivated fields are the chief source of the thin, hard sediment deposited in reservoirs. Trough furrows prevent the formation of sediment runoff.

Trough furrows are very practical because they can be prepared before the advent of rains that often assume downpour proportions and cause severe erosion damage.

By holding back surface runoff, the troughs help decrease the amount of water in the channels of surface streams and gullies, and so decrease linear erosion and the transfer of sediment to river channels. They are most important in preventing silting in reservoirs.

The foregoing facts give the many-sided benefits derived from the use of trough-furrow hilling in agricultural practice. Its one disadvantag is the fact that trough furrows somewhat increase surface evaporation, and thereby decrease the waterholding effect. We have no studied this phenomenon, but believe that th extra evaporation is less than the extra moistur absorption. Whenever the values are the same the erosion-controlling and sediment-retaining effect of trough furrows remains.

The practice of hilling in trough furrows is very general in Bulgaria, under various conditions. Numerous questions arise, pertaining to width, length, depth, direction, and so forth These will be posed and answered in the course of work.

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Discussions

A COMPARATIVE GEOGRAPHICAL STUDY OF CLIMATIC CONDITIONS OF CHERNOZEM FORMATION (Contribution to a Discussion of Chernozem Classification)

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The basic morphology of the soil profile and its physical, chemical and other properties is the most briefly mentioned feature of a soil group. Our understanding of a soil group can be deepened by a description of the conditions under which it is formed: the climate, vegetation, parent material and topography of the locality. It can be expanded still further by a knowledge of the dynamics of the processes that have produced the natural body—the soil of a given group. The main indications of a soil group are most fully known when in juxtaposition with soils of other groups; the distinguishing features of the soil group and the limits of variation appear to the fullest extent only when contrasted with those of other soil groups. These statements are true of both the group indices of soils as natural objects and conditions of their formation. This includes the vast knowledge encompassed by soil science in its establishment, growth and present application—the comparative geographic method. The author undertakes to describe the climatic conditions governing formation of chernozem soils, primarily through a comparative geographic study of data on seasonal phases of the climate.

In establishing the basic features of chernozems, as well as conditions under which soils of this group are formed, a study of the ways in which chernozems change in two geographic directions was made: toward the south, into chestnut-soils, and toward the north, into podzols. At the present time, sufficient data on the chernozem properties of various regions have been accumulated and ecologic conditions under which chernozems exist have been discovered. It has become evident that the position occupied by chernozems in the foregoing sequence—podzols, chernozems, chestnut soils—is only one case among many involving transition of chernozems into many other soil groups.

It would be profitable to examine the nature of the transitions from chernozems to other soil types as embodied in the specific geographic examples. The areal distribution of chernozems and the conditions under which they exist throughout Eurasia has been taken as such an example. The chernozem distribution in Eurasia is given on the basis of a number of published soil maps, both composite maps for individual countries (11, 16) and more detailed maps of the chernozem distribution in individual districts (3); thus a general picture of the areal distribution of chernozems has been obtained (Fig. 1). In this distribution one may distinguish a region in which the chernozem occurs both extensively and, as it were, continuously in a body of soil; outside this basic zone the distribution is contracted into separate narrow belts or islands. It may be noted that chernozem thins out in four main directions: Northern European, Southern European, Central Asiatic and Eastern. The chernozem changes northward and southward into other soil groups through a number of transitional zones.

There can be no doubt that the complex distribution area of chernozem reflects differences in its ecology—in the conditions of its formation in different regions. The formation of chernozems is associated with steppe and meadow-steppe types of sod-forming vegetation. A comparison of the chernozem distribution area with a map of the distribution of vegetation zones (4, 14) very clearly shows the link between chernozems and typical (sod and grassy) steppes and other steppes, although there are some notable discrepancies. In the Northern European part of the chernozem area the chernozem occurs in places that the map indicates as having once been covered with forest vegetation. This discrepancy is evidently due to definite historical and genetic relation-

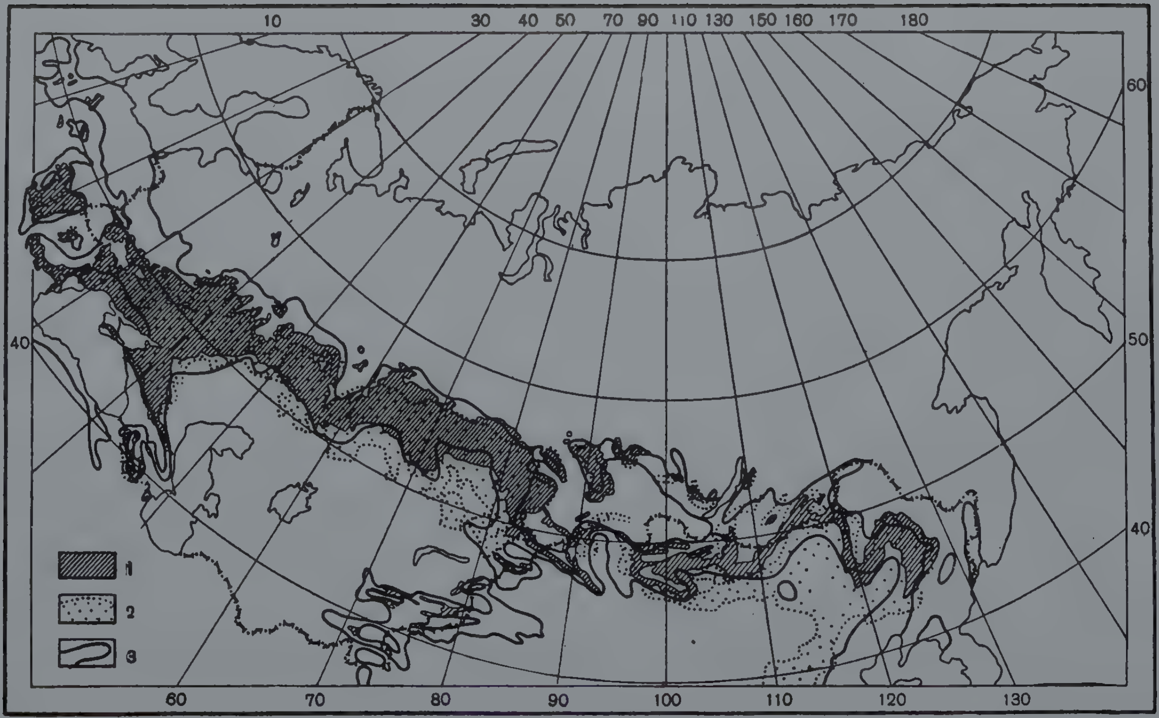

FIG. 1.—The areal distribution area and the vegetation and climatic conditions associated with chernozems in the northern part of Eurasia. 1—chernozem areas; 2—meadow and typical steppe areas; 3—outer boundaries of hydrologic zones D and DE within thermal zones III, IV and V.

TABLE 1

Climatic conditions of typical chernozem districts

(according to data from Selyaninov, 12, and Orlova, 10)

Districts	Climatic indices	Months												Year	Hydrologic zone
		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
Krasnodar (leached chernozems)	t	−2.1	−0.1	5.0	10.6	16.7	20.4	23.7	22.9	17.6	12.2	5.3	1.1	11.0	DE (D)
	P	59	49	46	53	44	67	60	33	67	47	58	66	649	
	W	85	85	79	75	71	73	67	63	71	78	84	87	76	
Rostov-on-Don (carbonate chernozems)	t	−6.1	−4.0	1.0	9.0	16.8	20.7	23.7	22.8	16.5	9.8	2.3	−2.5	9.2	D
	P	35	36	33	34	43	62	56	31	31	33	38	39	470	
	W	86	87	84	68	62	65	59	55	63	73	84	88	72	
Voroshilovgrad (southern chernozems)	t	−7.0	−5.3	0.1	8.4	16.0	19.6	22.2	20.7	14.6	8.0	1.1	−3.5	7.9	D
	P	26	27	32	36	50	62	58	36	34	35	38	35	469	
	W	81	80	78	64	59	64	61	58	64	71	80	84	71	
Poltava (typical chernozems—leached chernozems)	t	−7.3	−5.8	−1.1	7.1	14.9	18.0	20.6	19.4	14.1	7.4	0.2	−4.5	6.9	D
	P	21	20	32	29	36	70	66	52	24	40	32	29	451	
	W	88	86	83	66	57	62	60	58	62	71	80	83	71	
Chkalov (ordinary chernozems—southern chernozems)	t	−15.4	−13.5	−7.4	4.0	14.8	19.7	22.0	19.7	13.0	4.2	−4.6	−11.0	3.8	D
	P	34	22	21	24	39	44	31	35	26	29	42	38	385	
	W	87	86	85	75	69	61	56	60	65	78	87	86	74	
Omsk (ordinary chernozems)	t	−19.1	−18.1	−11.3	0.2	10.6	16.6	18.9	15.9	10.3	1.6	−8.6	−16.5	0.0	D
	P	12	8	10	17	28	56	70	53	34	22	17	14	341	
Tatarsk (ordinary chernozems)	t	−19.2	−18.5	−11.8	−0.8	10.2	16.5	18.7	15.8	9.9	1.2	−9.2	16.5	−0.3	D
	P	13	9	11	16	27	50	64	48	29	20	21	17	325	
	W	83	82	82	76	62	67	73	75	75	80	86	85		

Note: t = temperature, °C.; P = precipitation, mm.; W = relative humidity of the air, %.

hips. There is also a considerable discrepancy between the chernozem distribution area and steppe vegetation in the east, where within the eastern districts of the Mongolian People's Republic and the interior of Northeastern China, typical (sod and grassy) steppes extend south and southwest far beyond the chernozem soil.

Let us review the climatic conditions under which chernozems occur. From an examination of the basic climatic factors—precipitation and temperature—it would appear at first glance from Table 1 that the climatic conditions of chernozems are essentially varied and difficult o characterize. Nevertheless, there are some general features in the intake and loss of moisure. All the cases cited in the Table fall within one range of the hydrothermal system—the D hydrologic range (2, 3), in which the moisture property is balanced, so that there is only as much precipitation as can evaporate under the iven influx of heat (characterized by the mean nnual temperature). Properly speaking, the onclusion that chernozems are associated with onditions of balanced moisture is not a new one. However, the principle that the climatic conitions of moisture can be characterized by a ingle hydrothermal system expressing the genral laws governing the intake and loss of moisture in a given geographic area, in association with the temperature is new.

The association of chernozems with climatic conditions characterized by a moisture balance of type D is no less evident from a comparison of the geographic distribution of the chernozems with that of the hydrologic zones D and DE (steppe and forest-steppe). The greatest area occupied by the chernozems within the overall limits of the hydrologic zones D and DE is in the center, extending mainly from the Carpathians in the west to the Altai in the east. An examination of temperature data will show that this part of the hydrologic zones D and DE is characterized by the thermal conditions of thermal range IV—that is, it corresponds to the hydrothermal types DIV and DEIV. It will be recalled that the hydrothermal type DIV is "typical" of chernozems.

On the basis of the established correspondence between the chernozem area and the D and DE hydrologic zones it would be erroneous to say that this known type of moisture equilibrium was the only determining factor in chernozem development. A different conclusion must be drawn. It follows from the fact that the chernozems have a narrower distribution than that of the hydrologic zones D and DE that a "bal-

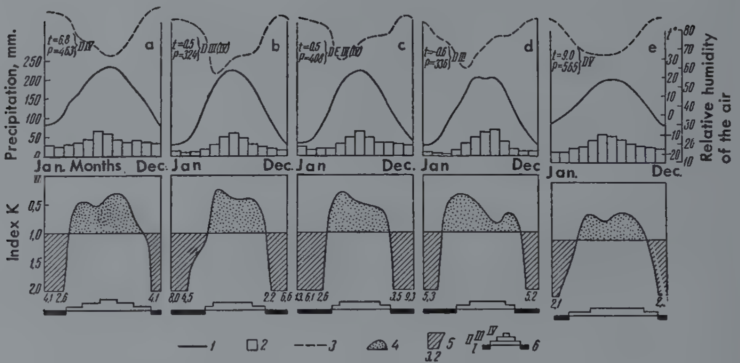

FIG. 2.—Hydrothermal conditions in basic chernozem areas. a—chernozems of the European part of the Soviet Union; b—Siberian and Kazakhstan chernozems; c—Altai chernozems; d—Eastern Siberian chernozems; e—chernozems of Central Europe. 1—air temperature in degrees; 2—monthly precipitation in mm.; 3—relative humidity of the air, %; 4—periods in which the index K_m = precipitation/evaporation is less than unity; 5—periods in which K_m is greater than unity; 6—temperature levels of soil formation (I—less than 0°C., II—from 0° to 10°C., III—from 10° to 20°C., IV—greater than 20°C.).

anced" type of moisture equilibrium is only one of the climatic factors governing the existence of chernozems. To discover the other climatic conditions important in the development of chernozems a more detailed examination must be made both in the principal areas and in transitional zones. They will be determined for very large geographic areas without undertaking to define subzones or provincial chernozem subgroups. Four regions—the European part of the USSR, Western Siberia and Kazakhstan, the Altai and Eastern Siberia—will illustrate geographic regions in which chernozems are widespread. Climatic data that form the basis of the graphs have been taken for each region from readings recorded by from three to fifteen meteorologic stations, generally one with climatic type.

The connection between the chernozems and hydrologic range D may be seen from Fig. 2 a, b, c, d; only the weather stations throughout the Altai area have indicated a somewhat higher amount of moisture (DE). Atmospheric precipitation, however, is quite varied. Within the European part of the USSR chernozems are characterized by conditions of relatively uniform precipitation throughout the year, with only a small increase in summer. In Eastern Siberia, precipitation over the chernozem area varies from a small amount in winter to a sharply increased maximum in summer. There is essentially a general trend, however, in the changes in the relative moisture during the course of the year. If these differences are judged according to changes in the magnitude of K_m = precipitation evaporation (the evaporation being computed according to N. N. Ivanov's method)[1] it becomes very clear that there is a summer period of relative desiccation. The dry season is also clearly discernible in the changing relative humidity, which, during most of the period characterized by low values of K_m, is less than 70%. During the winter period, K_m is much greater than 1, and the relative humidity is also high—from 70 to 85%.

The changes in temperature are also typical of chernozem areas. Chernozems are formed under conditions in which the summer temperatures are fairly constant, changing only within the limits of 15 to 20° C., but in which there are very great differences in the winter temperatures, which vary on the average from somewhat higher than 10°C. (in the west) to 20°C. (in the east). These temperature differences are associated with the change in the continental nature of the climate.

Let us turn to the conditions characterizing the transitional chernozems. The principal transitions—into chestnut-soils and podzols—are quite clear. Here we shall merely note such aspects of the sod-podzol-soil groups as their association with conditions of increased moisture (E), the long duration of the leaching period, the shortened summer period of evaporation in excess of precipitation, the excess being small ($K_m = 0.6 - 1.0$). In the chestnut soil area there is a hydrologic equilibrium with a distinct moisture deficiency (C, CD) during a lengthy period in which the soils are considerably dried out, when K_m varies between 0.1 and 0.4 and the relative humidity drops to 48 to 50%. The temperature of the areas with podzols and chestnut-soils are quite similar to those of the chernozem areas of the same region (The European part of the USSR), but the periods of different temperature levels are in different relationships to the changes in soil moisture.

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[1] N. N. Ivanov. 1941. Zony uvlazhneniya zemnogo shara (Moisture zones of the earth). Izv. Akad. Nauk SSSR, ser. geograf. i geofiz. No. 3.

The chernozems of the southern areas of the European part of the USSR, which have higher mean annual temperatures than the eastern regions, are formed under conditions of shorter frost periods (mean monthly temperatures below 0° C.) and hotter summers (mean monthly temperatures somewhat higher than 20° C.). These differences become even greater farther on, as the mean annual temperatures increase until the conditions of thermal range VI are reached, in which the period with mean monthly temperatures below 0° C. is completely lacking, as is the case in subtropical climates. The climatic conditions of hydrothermal types DVI and DEVI already exist in the areas containing soils of the cinnamon-brown soil association with the same soil group as that of cinnamon-brown soils. This very seasonal trend in the changes in the climatic factors, which accompanies the transition within a very short distance from chernozems and gray forest soils to cinnamon-brown and other associated soils, may easily be traced in Bulgaria and beyond in the Balkan Peninsula. Graphs have been drawn of this transition in ecology and soil type for areas with two groups of soils: for areas that contain cinnamon-brown soils and smolnitsy and for the northeastern and northern Mediterranean areas in which brown soils are encountered.

In both cases the soils are associated with type D moisture conditions, with mean annual temperatures typical of thermal range VI—in the cinnamon-brown soil (Mediterranean) areas and in the nearby areas that contain cinnamon-brown soils along with chernozems. In both cases, however, the pattern of annual temperatures is the same: there is no period with temperatures below 0° C., and there is a long summer with high temperatures (20 to 25°C.). There is little basis for finding any specific features in the seasonal moisture of the cinnamon-brown soils in these areas. Mediterranean region cinnamon-brown soils exist under conditioins of minimum precipitation and a short period of considerable dryness in summer (to judge by K_m and the relative humidity of the air)—the same conditions that I. P. Gerasimov has pointed out as being typical of cinnamon-brown soils (5, 6). In Bulgaria cinnamon-brown soils are also associated with warm winters and summers in which there is a maximum of precipitation. Consequently, no essential difference has been noted in regard to the season of moisture deficiency (the period for which $K_m < 1$) between the cinnamon-brown-soil and chernozem regions. It is evidently correct to conclude that cinnamon-brown soils of the Mediterranean and Eastern Europe[2] are formed under the following hydrothermal conditions: a generally balanced moisture equilibrium (type D), a moderately warm winter (without months of constant frost), spring-summer and autumn phases of active soil formation (with temperatures from 10 to 20° C. and sufficient moisture), and a summer phase of moderate temporary desiccation with temperatures higher than 20 to 25°C.

Let us move on to the conditions that accompany the occurrence of chernozems in the northwestern periphery of the chernozem area. Here the chernozems are found as "islands" among other groups of soil—primarily forest soils.

From the hydrothermal graph (Fig. 2e) one can see that according to the mean annual temperature (9.0°C) and the precipitation (565 mm.), the whole group of Western European chernozems exists under "chernozem" conditions characterized by a hydrologic equilibrium of type D; the geographic "islands of chernozems" belong to areas in the hydrologic zone D, DE.

Here the seasonal changes in hydrothermal indices are also typical of chernozems: wet, icy winters coupled with long, warm summers during which there is some precipitation but insufficient soil moisture.

The recurrent values of K_m and of the

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[2] The climatic conditions associated with the formation of the cinnamon-brown soils of China and other regions are not considered in this article.

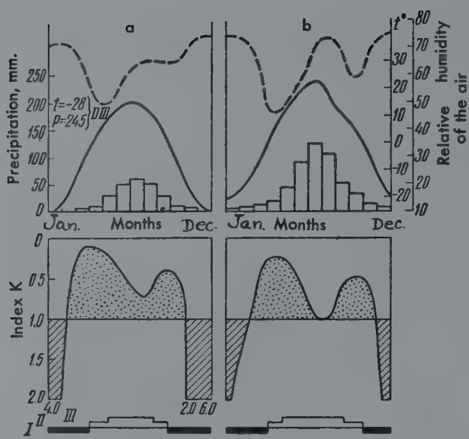

FIG. 3.—Hydrothermal conditions in the chernozem areas of Mongolia (a) and Manchuria (b). (For key to symbols, see Fig. 2.)

relative humidity of the air are very close to those typical of the main distribution areas of chernozems. The soil moisture in the chernozem areas of Western Europe differs from the norm only in the somewhat higher values of K_m during the summer period. Thus, whereas in chernozem areas K_m typically varies between 0.4 and 0.6, the usual value of K_m for chernozems of Western Europe is about 0.6. Possibly the somewhat increased moisture during the summer is the reason for the indications of leaching (and perhaps, meadow-like properties?) that are to be seen in these chernozems. Thus the chernozems of Western Europe, as compared to the group of leached and podzol-type soils, are actually developed under the hydrothermal conditions typical of chernozem formation.

On the eastern periphery of the chernozem distribution area one must distinguish two basic changes in the properties of the chernozems: one in the direction of the interior of Mongolia (1) and the other in the direction of the Far Eastern shore.

The hydrothermal graph in Fig. 3a has been drawn on the basis of data from a more detailed investigation of climatic conditions of chernozems in Mongolia. In constructing this graph, data were used from two points (Ulan-Bator and Ulyasutai) which are shown on existing maps as belonging to the zone of dark chestnut soils but, according to the mean annual temperature, and the annual precipitation, belong to hydrologic zone DIII–that is, to th "chernozem" zone. The hydrothermal chart als shows convincingly that the climate is typica of chernozem regions: there are winters of freezing temperatures and periods of desiccation i summer.

In this case the hydrothermal conditions possess certain distinctive features. There are sma amounts of atmospheric precipitation and evaporation in winter, so that K_m has values abov those of a balanced equilibrium ($K_m = 2$ to 6). The relative humidity of the air in winter i also higher (70 to 75%). The summer period i somewhat longer and at times drier than in other chernozem areas. The lower humus content of these chernozems is evidently due to these facts.

Thus in certain steppe areas of Mongolia which the soil maps show as belonging to the dark chestnut soil zone, the hydrothermal climatic conditions possess features typical of chernozem regions. Without attempting to decide here whether the published maps have correctly assigned the known steppe soils of Mongolia to the dark chestnut group, rather than to the chernozem group, it is nevertheless expedient to devote some attention to certain aspects suggesting that chernozems are more widespread than they are presently shown to be.

The chernozems of Northeastern China, according to Rozov's map (11), are found in the following geographic series: 1) dark chestnut—ordinary chernozems—leached chernozems—gray mountain forest soils—mountain podzols, and 2) dark chestnut soils—ordinary chernozems—leached chernozems—gray forest soils—mountain forest soils—brown soils. The natural vegetation of the zone in which these chernozems are distributed is that of the steppes and meadow-steppes, with a great development of sod vegetation (grasses, various meadow grasses and brushwood). Along with this, there are such distinguishing features of the chernozem soils here as the increased moisture (13).

Figure 3b shows that the leached chernozems of Manchuria are characterized by two distinct dry periods: one in spring-summer and one in summer-autumn. Although these two periods are separated by rains in mid-summer, the dry period in general has the length typical of that of chernozem formation. The considerable degree of desiccation during these periods is very well indicated by the low relative humidity of the air, especially in the second period when it falls below 50%. But considerable moisture in the middle of the summer should give the soil certain peculiar features taking the form of a "meadow-like" character (16, 9, 7).

The various examples chosen above do not begin to exhaust the number of transitions that exist in nature from chernozems to soils of other types. It would no doubt be useful to investigate the transition from chernozems to the sod soils of the low-temperature belts and from chernozems to certain mountain soils as in the Caucasus or in the Tien-Shan mountain region, where there are a number of very peculiar transitions. Some peculiar features of the climate will also be observed. But the author considers that the foregoing relationships between soil and climate will merely produce additional known information on the formation of chernozems under various soil and climatic conditions.

The climatic conditions governing the existence of chernozems that have been chosen for analysis suggest certain general conclusions in regard to the hydrothermal regime of chernozem formation (Fig. 4):

1) a balanced hydrologic equilibrium resulting in a fairly high soil moisture without leading to thorough leaching;

2) a moisture regime that is very favorable to the growth of grassy vegetation, and an intensive temporary seasonal migration of the material within the soil profile;

3) freezing during the period of increased moisture in the soil as a factor in chernozem formation;

4) a definite succession of seasonal phases of soil formation, as follows:

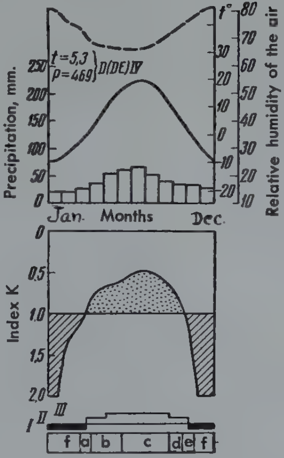

FIG. 4.—Generalized summary of the hydrothermal conditions in chernozem areas (averaged data). The symbols a, b, c, d, e, and f indicate seasonal phases of soil formation. (For explanation see text and caption to Fig. 2.)

a) an early spring phase of rising temperatures, melting snows and thawing of the ground, accompanied by super-saturation of the soil and the development of anaerobic processes; b) a spring-summer phase in which the hydrothermal and biological conditions are at an optimum for the growth of grassy vegetation, the accumulation of surface vegetation and subsurface root masses and the use of mineral substances in the structure of this mass of vegetable matter; c) a summer-autumn phase of alternate moistening and desiccation of the soil, along with decomposition of the vegetable matter, its transformation into humus compounds and the formation of mineral-organic complexes; d) an autumn phase of falling temperatures and saturation of the soil with moisture; e) a late autumn phase of intermittent, ever-increasing freezing of the soil and thermal denaturing of the humus substances; f) a winter phase with constant temperatures below zero and snow covering the ground for most of the period—a phase of reduced biologic activity and increasing reducing conditions.

All these conditions are important in the formation of chernozems. The exclusion of even one of them would cause a definite shift toward the formation of another genetic group of soil. In addition, a weakening or intensification of some aspect of the hydrothermal conditions when all other aspects are present will produce peculiar features and provincial peculiarities in the soil.

The hydrothermal indices that have been mentioned as prevailing in regions in which chernozems are distributed are important not only in the formation of this soil group but are equally significant for all other soil groups that paragenetically accompany the chernozems (gray forest soils, chernozem-meadow soils, solodi, and others). The combination of hydrothermal indices previously mentioned may be taken as a definite type of bioclimatic conditions (type D, DEIII-V) with which soil formation in chernozem regions is associated.

In conclusion, we must stress that these analyses of chernozem formation were based primarily on climatic data. The phases of chernozem formation should be examined further in the light of results of more extensive stationary investigations.

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CLASSIFICATION OF BOTTOM LAND SOILS IN THE FOREST ZONE

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CLASSIFICATION is one of the most difficult problems in soil science. It has to represent he total sum of soil knowledge as systematically nd concisely as possible and also has to facili-ate the search for new methods of scientific investigation of soils and their most efficient use or agriculture. With the development of science nd the broadening of our knowledge, the neces-ity periodically arises for further improvement of existing classifications.

We consider the classification of bottom land oils to be the least complete. The most divergent points of view exist regarding the genesis of bottom land soils, the nomenclature of which s quite confused. It is easy to demonstrate that completely different bottom land soils appear under similar names in our literature, while dentical soils bear dissimilar names. Every soil cientist studying bottom land soils has encountered this situation. This author was no exception when he investivated bottom land soils n the valleys of the Moscow, Klyazma, Oka, Kama, Vyatka, Don and other rivers. The material accumulated during his studies on the more important characteristics of bottom land soil formation induced the author to present his views on the classification of these soils.

According to V. V. Dokuchayev's classification, bottom land soils are separated from the class of alluvial soils and are classified with the abnormal ones. In Dokuchayev's opinion, the latter do not represent typical soils and belong as much to geology as to soil science (7, p. 247, 380).

Analyzing positive and negative aspects of Dokuchayev's classification, N. M. Sibirtsev remarked that in regard to bottom land soils this classification does not show a definite line of demarcation between soil in the narrow meaning of the word and an alluvial deposit, which is a geological formation (19, p. 304). In Sibirtsev's classification, bottom land soils are grouped with the azonal soils. He gave, moreover, a clear definition: "One should not confuse an alluvial deposit with an alluvial soil. An alluvial deposit is a purely mechanical deposit, quite varied in thickness (up to few sazhens); alluvial soil is the horizon of this deposit, which is subjected to the influence of the general dynamic factors of soil formation." (19, p. 311).

In 1909, Polinov (14) described the mature meadow bottom land soils which he thought should be regarded as intrazonal soils, as they depended in their genesis on the formation of the bottom land. This work contains the first justification for the separate nature of the formation of bottom land. Later, unfortunately, while soil classification was being elaborated, bottom land soils were almost entirely ignored. K. D. Glinka maintained that bottom land soils (alluvial) should not be separated at all, as in most cases they can either be grouped, depending on their characteristics with bog, podzolic, solonetz-like, or other soils, or (in case soil formation is masked by the alluvial process) they should be regarded not as soils, but as an alluvium—a mechanical deposit (5, p. 303).

Afanas'yev defended a similar point of view (1). He felt that soil classification should be concerned only with "developed and completely normal (healthy) objects", which he did not consider bottom land soils to be.

It is true that in most cases, we find characteristics such as podzolization and solonetzation appearing in bottom land soils that are located in areas of rarely flooded bottom lands or in areas no longer subject to inundation. These soils, therefore, are not typically bottom lands. Also, vast areas of bottom lands of rivers are covered every year with flooded peat meadow soils showing no signs of podzolization, solonetzation, or stagnation processes. What shall be done with these soils? Shall we refuse to classify them because they are "undeveloped," "abnormal," or "unhealthy"? These are often superior, highly fertile soils, especially in the zone of podzolic soils. Furthermore, they generally have many properties that are characteristic only of bottom land soils.

This tendency to exclude bottom land soils from the general classification (against which Dokuchayev warned in his time [7, pp. 247]) and the reluctance to further develop their classification reflected, in our opinion, very little knowledge of their properties as well as their marked dissimilarity to zonal types of soils.

The greatest successes in the studies on bottom land soils are associated with the name of Vil'yams (3). He was not especially concerned with classification problems, but his teachings on the genesis and development of bottom land soils decisively influenced the subsequent course of classification of these soils. Vil'yams' theory on the peat-forming process, separation of bottom land into genetic divisions (river-bed, central and terrace zones) and explanation of the mechanism of formation of granulated and stratified types of bottom land were especially significant. Vil'yams' theories are reflected, in a greater or lesser degree, in most of the subsequent work on bottom land soils, including classification.

Since 1920 our rapidly developing national agriculture, especially the growth of rural agriculture and hydrotechnical construction, has stimulated large-scale investigation of the soils of river valleys. A great number of studies on bottom land soils were completed and in part published. In most of them questions of classification were naturally raised. We shall not attempt to analyze all of these works, but shall direct our attention only to those that were of theoretical significance in the classification of bottom land soils.

In the well known work of L. I. Prasolova and N. N. Sokolova on bottom land soils in the district of the Volkhov River and Lake Il'men' (15), the existing bottom land soils are subdivided into alluvial stratified and alluvial nonstratified, the latter being represented chiefly by alluvial-meadow and alluvial-bog soils. Alluvial-meadow soils form as the result of the peat-meadow stage of soil formation which, in the opinion of the authors, is very characteristic of bottom lands.

In 1938, I. I. Plyusnin on the basis of Vil'yams' theory on bottom land soils worked out a detailed classification of the Volga-Akhtuba bottom land soils (12). Plyusnin considers the meadow alluvial type of soil formation to be the most characteristic for typical bottom land conditions. He subdivides meadow soils into these subgroups: alluvial meadow, alluvial-lagoona meadow, bottom soil esturarian meadow an alluvial-deluvial meadow.

Within the subgroup of alluvial meadow soil he identified three classes: 1) the youngest accumulative soils of the river bed; 2) the oldes (developed) sod soils of the central granular bottom land; 3) accumulative-sod soils of the stratified central bottom land which occupies a intermediate position between them. The soi classes are then subdivided into stages accordin to the degree of formation and expression of different features (stratification, granulation, thickness, and so on).

In 1949, Plyusnin published a new classification encompassing the soils of river valleys (bottom lands and bottom land terraces of forest forest-steppe and steppe natural zones) (13) The following typical soils are identified in this classification as typical of bottom land conditions: 1. primitive bottom land; 2. meadow bottom land; 3. bog bottom land; 4. salinized bottom land.

The term "primitive soils" means overgrown with alluvium. Meadow soils are subdivided into these subgroups: 1. alluvial-accumulative; 2. alluvial-accumulative sod; 3. sod soils. Bog bottom land soils are subdivided into muck-bog and peat-bog soils. A further subdivision into species and varieties of soils is done according to such criteria as stratification, granulation thickness, gleying, peat process, texture, and so on. It is important to observe that in Plyusnin's classification sod soils are considered a subgroup of meadow bottom land soils and that stratification and granulation are considered as species criteria and are not used as the basis for subdividing the bottom land soils into main groups.

In 1940, Rod, Afanas'yeva and Grabovskaya published their work on the river valley soils in the podzolic zone of the European part of the USSR (16). This monograph is distinguished by the richness of analytical material which provided the first detailed description of the chemical properties of bottom land soils in the forest zone. In the authors' opinion, bottom land soils form as a result of the combination of two processes: alluvial and podzolic; hence they are named alluvial-podzolic soils.

Yarkov's classification of bottom land soils embracing the main natural zones was published in 1945 (21). This classification gives the impression of being a systematic, nomenclatural list since it does not give a genetic analysis of bottom land soil formation or the emerging principles on which the classification is based. The term "sod soil" (stratified sod, sod soil of stratified bottom land, sod soil of granulated bottom land, dark-colored sod soil of swamp alder, and so forth) is the basis for the nomenclature of most soils along the river of the central, and, in part, of the terrace portions of bottom land.

The works of Kovda (10, 11) and Iozefovich (9) had great theoretical significance for the correct understanding of the genesis of bottom land soils and the development of their classification. The authors showed that the evolution of bottom land soils is characterized by a gradual intensification of the role of surface-biological factors and by the diminishing role of water. V. A. Kovda also directed attention to the fact that meadow-sod soils form not only on fresh alluvium but also as a result of the evolution of bottom land bogs. This observation found further development in the literature on bottom land soils (4, 6).

In 1953, Shrag published his classification of bottom land soils (20). Shrag tried to base his classification on the origin and development of bottom land soils, differentiating three stages of soil formation. The first stage includes the youngest soils with the rudimentary signs of soil formation; the second stage includes more developed bottom land soils without their having the characteristics of zonal soils; and the third stage includes bottom land soils with the clearly visible characteristics of zonal soil formation. Within each of these stages soil varieties are differentiated by the degree of visibility of the processes of soil formation and such conditions as the character of the alluvial process and of bottom land formation, soil adaptation to physico-geographical zones and to geomorphological elements of bottom land. A brief description is given for each variety of soil.

The general principles that the author tried to use as a basis for his classification are absolutely correct. The merit of this classification is that it provides a much clearer characterization of every variety of bottom land soil than the previous systems. In this respect, Shrag's work is undoubtedly a step forward in the solution of classification problems. At the same time it has, in our opinion, substantial shortcomings.

In many instances the genetic interrelations of varieties of bottom land soils within the stage limits are not quite clear, which gives the classification the character of a systematic list. Even the author notes this fact. Some questions of terminology and soil nomenclature are not clear, especially the assignment of the term "sod soils" to some soils and the term "meadow soils" to others. V. I. Shrag considers it correct to keep the terms "stratified soil, stratified-granulated and granulated" as genetic terms. We consider it sounder to use the terms "stratified or granulated" only for the morphological characteristics of soil or bottom land alluvium. The clumsiness and lack of logical consistency of the classification, which makes it difficult to remember and to use, are additional shortcomings.

As a result of his investigation of the Oka River bottom land soils, D. G. Vilenskiy (2) came to the conclusion that at the present time the sod process of soil formation is developing on the bottom land and that the sod-meadow soils are the results of this process. Within this group there are several subgroups: weakly developed sod and sod soils of river-bed stratified bottom land, sod-meadow and meadow soils of central granulated bottom land, and meadow-bog soils of terrace bottom land. Sod-podzolic and gray forest soils are also described in the bottom land of Oka River.

In Vilenskiy's classification of Oka River bottom land soils, one should especially observe the distinction between sod soils and meadow soils with respect to the differing character of the water regime and several other properties. Nevertheless, these differences are apparently not considered significant enough to warrant their being classified as separate groups of bottom land soils. As already mentioned, Vilenskiy regards sod and meadow soils as subgroups of the same sod-meadow group of soil.

Ivanova, in her work published in 1956 (8) on classification of soils in the northern part of the European territory of USSR, distinguished three groups of bottom land soils: alluvial bottom land ("stratified bottom land"), sod bottom land soils (meadow, "granulated bottom land"), and alluvial bog bottom land soils. The subdivision of bottom land soils into three groups (and not just into subgroups) seems to us to be quite correct. However, the names of the types of bottom land soils, their treatment, and subdivision require further work and more precision.

We do not understand, for example, why the term "alluvial" is assigned to stratified and bog bottom land soils, but not to sod bottom land soils. If the desire was to stress the weakening of the alluvial process in sod soils, then why is the term alluvial kept for all bog bottom land soils in which the alluvial process is often even less pronounced than in sod soils? In general, the term alluvial, in our opinion, should not be used, as it refers only to the parent material of bottom land soils and indicates nothing about the properties of the strictly soil processes under the conditions of bottom land.

Sod bottom land soils are also called meadow soils. We have had the occasion to remark (6) that arbitrary use of the terms "sod," "meadow," "sod-meadow," "meadow-sod" soil, brings confusion into the nomenclature of soils. Quite recently we went into this problem in more detail (18).

Even this short survey of the classification of bottom land soils shows its inadequacy and the need for further work on the subject.

The classification of bottom land soils of the forest zone (Table 1) proposed in this article is based on characteristics of the formation and evolution of bottom land soils, which we set forth earlier (6). We shall not repeat them here, but only add the necessary explanations for the classification.

The conditions of soil formation, soil properties, and methods of agricultural utilization are so different in various genetic regions of bottom land that it is absolutely necessary to speak of different groups of bottom land soils. In typical bottom lands (flooded yearly or comparatively rarely not flooded) three groups of soils are clearly discernible, which we propose to call sod bottom land soils (sod-forest), meadow bottom land (meadow-forest), and bog bottom land (bog-forest). Each of these groups of bottom land soils is characterized by: a) Specific structure of the soil profile. b) Specific characteristics of the air-water regime and nutrient system. c) Quantitative and qualitative properties of the biological cycle of elements. d) Specific composition of flora and fauna. e) Prevailing distribution in certain genetic regions of bottom land and on certain elements of the relief. f) Specific methods of reclamation and agricultural utilization.

Sod bottom land soils are formed by the sod process, meadow soils by the meadow process and bog soils by the bog process.

Most soil scientists recognize the independence and clear delineation of the bog process of soi formation; therefore, the need of distinguishing the bog process in bottom lands needs no justification. However, it is different with the meadow and sod processes. In most cases the meadow process is either regarded as a stage in the sod process or is identified with it. The lack of agreement on this subject hinders the establishment of appropriate terminology.

The concept "meadow" in soil literature is largely tied in with the notion of greater soi moisture, due principally to soil-ground waters. We need only mention meadow-chernozem, meadow-chestnut, meadow-sierozem soils. Hydromorphic or automorphic-hydromorphic conditions of soil formation are mostly associated with the terms "meadow soil" and "meadow process," with a definite ground-atmospheric type water system in the soil and a continuous ground-capillary moistening (17). Ground nourishment of the soil imparts to it specific properties of the water regime, and also influences in a profound way the entire complex of biological and chemical processes as well as the relations between biological and geological cycles of substances in the soil.

The processes of soil formation under the condition of ground supply and under conditions of atmospheric supply are different in principle and result in the formation of different soils Since the automorphic or hydromorphic conditions of soil formation are not the consequence of soil formation itself, the meadow process can in no way be regarded either as a part or stage of the sod process, nor can it be identified with it. It is therefore more correct to regard them as independent processes forming different groups of soils, namely, meadow and sod.

We propose to assign the term sod process to that process of soil formation which develops under the influence of grass vegetation where there is moistening of the soil only by surface waters, and which is accompanied by the accumulation of humus and biogenous elements in the soil.

The meadow process develops under conditions of atmospheric-soil moistening and because of this is accompanied by the accumulation of humus and biogenous elements, and also, in conrast to the sod process, by the hydrogenous acumulation of elements from ground waters.

The bog process takes place under the conlitions of river bottom land with an excess of oil moisture, lack of aeration, and periodic looding. This brings about the accumulation of umus and of poorly decomposed plant residues, nd also of elements brought out by ground and lood waters from terraces and watersheds.

Insufficient knowledge of the soils of forest ottom lands causes serious difficulties in the lassification of bottom land soils. The theory hat forests were the primary vegetation of iver bottom lands is apparently correct; thereore, soils under the present bottom land meadws are residual forest soils that were afterwards ither "sodded" or "meadowed". What are the oils of forest bottom lands? What are their roperties and how should they be classified and amed? There are no answers as yet to these uestions. These soils are as varied among themelves as soils of meadow bottom lands. Thereore, we do not consider it worthwhile to introluce into the nomenclature of all bottom land oils the evidence of their forest origin, as we re doing, for example, in reference to zonal ray forest soils. Since the soil scientist studyng bottom land soils deals with meadows and astures in most cases, the term "forest" would nly complicate the nomenclature of bottom and soils. Besides, on vast areas of meadow ottom land new alluvium was deposited after he reduction of forest and thus had not been xposed to the influence of soil formation under forest cover. These circumstances prevent aplication of the term "forest soils" to all bottom and soils.

However, what shall be done with the soils f present forested bottom land? For example, o name the soil of oak bottom land meadow or od soil is clearly awkward, if not incorrect. It s imperative to differentiate the soils under eadow bottom land from those of forested ottom land when making large scale maps for gricultural use. We consider it advisable in decribing forested bottom land soils resembling ottom land sod meadow and bog soils to name hem bottom land of the sod-forest, meadoworest, and bog-forest soils. The study of soils of orested bottom land is absolutely necessary in rder to elucidate the genesis of bottom land oils; this will help to solve the problem of heir classification in the future.

We have taken as the basis for the future subdivision of soils within the sod, meadow and bog types the degree of development of the processes forming these soils. Within the sod groups, we have them ranging from weakly to strongly developed sod soils; within the meadow group—from thin meadow to thick meadow soils; within the bog type—from weakly developed, low humus clay gley soils to peat gley and peat-like soils. In this classification sod-meadow soils are treated as transitional between the sod and meadow soils, and meadow-bog soils as transitional between the meadow and bog soils.

In this article we have intentionally refrained from discussing questions of the evolution of bottom land soils, as these questions have already been analyzed (6). We shall merely emphasize the fact that we regard the groups of bottom land soils as being groups of soils closely related genetically by reciprocal transitions, developing as parts of a river valley in the general process of bottom land evolution.

Assuming that soil-ground waters have a stronger effect on the properties of meadow and bog bottom land soils, we divide meadow soils into acid meadow and neutral meadow, and bog soils into water-logged by soft water and water-logged by hard water. The importance of this subdivision from the scientific industrial and economic points of view needs little explanation.

Podzolic bottom land soils and bottom land soils of the gray forest group are classified separately. They are generally found on high waterless bottom lands and on rarely flooded parts of bottom land, in other words under the conditions of non-typical bottom lands. These soils are turning into zonal soils. Owing to exceptional instability of the flood-plain as a still developing terrace over which the bed of the river wanders constantly, the bottom land conditions often change in different portions of the flood-plain. Areas that have almost completely ceased to be flooded with spring freshets often are flooded yearly. If this renewal of flood-plain conditions is pronounced (as the consequence, for example, of a river bed breaking through along the old river bed) then we find buried soils and among them podzolic (or gray forest soils). We observe the superposition of the sod, meadow or bog processes when the renewal of flood-plain conditions comes about gradually (as the consequence of gradual shifting and approach of the

TABLE 1

Classification of Bottom Land Soils of Forest Zones

Bottom land soils form on alluvial deposits under conditions of periodic flooding. High intensity of soil formation processes characterizes river bottom lands, and is due to the fact that a minor biological cycle of plant nutrients develops in bottom lands at that section of the geological cycle where there is concentrated the intensive transfer of the elements that are not retained in the terraces and watersheds.

Soil groups of bottom lands				Soils of high bottom lands and rarely flooded parts of bottom land
Sod bottom land (sod-forest) group of soils	Meadow bottom land (forest-meadow) group of soils		Bog bottom land (forest-bog) group of soils	Podzolized soils of high bottom lands and bottom land soils of the northern forest type
Forms under conditions of moistening only with surface waters, is found preeminently under brome grass, mixed grasses grassy meadows and light oak stands on sloping banks of river bed bottom land.	Forms under the conditions of optimal, sometimes excessive moistening by surface and ground waters, is found chiefly under grassy and mixed grasses—grassy meadows and humid oak stands on the plain and sloping banks of central bottom land.		Forms under conditions of highly excessive moistening with ground and surface waters. Is found chiefly on the terrace area of bottom land on alder (alder-birch) and sedge grass bogs and on isolated portions among depressions of the relief on the central and river bed area of bottom land.	Podzolized soils form due to superimposition of podzolization on sod bottom land and meadow soils. Develop under conditions of visible weakening of bottom land conditions and breaking away from ground waters (in the case of podzolization of meadow soils).
Soil formation is accompanied by the accumulation of humus and the elements that are actively drawn into the biological cycle by the vegetation.	Soil formation is accompanied by the accumulation of humus and the elements contained in ground waters that are actively drawn into the biological cycle.		Soil formation is accompanied by the accumulation of humus, poorly decomposed plant residues, and elements brought by ground waters from terraces and watersheds.	Found on higher elevated, level, rarely flooded portions under mixed coniferous-deciduous forests and well-drained meadows, mostly in the central bottom land.
In the soil profile are absent signs of reduction processes, also absent are new formations from ground waters.	Soil profile is characterized by ferrous, manganese, carbonate and other new formations. The signs of gleying—from weakly manifested in sod-meadow soils to very strongly pronounced in meadow-bog soils—are common.		Soil profile is characterized by formation of peat, or humus-clay horizon, sharply pronounced gleying, and accumulation of new formations, like "bog ore," "meadow lime," vivianite, and others.	1. SOD PODZOLIZED
1. Sod weakly developed soils Thickness of humus horizon <10 cm, marked stratification even of the upper horizon. Brome grass meadows, osier beds of river bed banks	*a) Acid* Often ferrated with Fe and Mn ortsteins 1. Sod-meadow acid	*b) Neutral* Usually without signs of Fe and Mn migration and accumulation, sometimes with calcareous new formations. 2. Sod-meadow neutral	a) Waterlogged with soft water b) Waterlogged with hard water	2. MEADOW PODZOLIZED 3. SECONDARY MEADOWED OR SODDED PODZOLIC SOILS OF BOTTOM LAND
2. Sod soils Thickness of humus horizon up to 20 cm, weakly expressed stratification of the upper horizon. Meadows of the higher elevated river bed bottom land, light oak stands	*Transitional from sod to meadow* Traces of periodic, brief moistening with ground waters (signs of gleying below, sometimes ortsteins)	Traces of periodic, brief moistening with ground waters (signs of gleying below)		4. SECONDARY MEADOWED OR SODDED BOTTOM LAND SOILS OF THE NORTHERN FOREST TYPE

TABLE 1—*Continued*

3. Deep-sod soils Thickness of humus horizons 20 to 40 cm. Meadows of the higher elevated central bottom land, light oak stands	Meadows of the higher elevated central bottom land and of the middle elevated river bed, light oak stands		Bogs, waterlogged meadows and alder forests chiefly on the terrace and; in lesser degree, on river bed and central portions of bottom land		
	2. Meadow thin acid Thickness of humus layer <30 cm	2. Meadow thin neutral Thickness of humus layer <30 cm	1. Weakly developed low humus Clay-iron-gleyed	1. Weakly developed low humus Clay-gleyed	
	3. Meadow acid (typical) Humus layer 30–50 cm	3. Meadow neutral (typical) Humus layer 30–50 cm	2. Humus-iron-gleyed	2. Humus-gleyed	
	4. Meadow thick acid Humus layer >50 cm Signs of prolonged moistening with ground waters, gleying of lower horizons, ferrated, ortsteins	4. Meadow thick neutral Humus layer >50 cm Signs of prolonged moistening with ground waters, gleying of lower horizons, sometimes calcareous new formations	3. Peat-iron-gleyed	3. Peat-humus-gleyed Peat-(humus)-gleyed calcareous	
	Meadows of the middle elevated central bottom land, humid oak stands				
	5. Meadow-bog acid	5. Meadow-bog neutral			
	Transitional from meadow to bog				
	Gleying throughout the profile down to peas, ferrous concretions and ortsteins	Gleying throughout the profile down to peat, sometimes calcareous new formations			
	Meadows of the lower elevated central bottom land and of the middle elevated terrace bottom land, gray oak-elm-aspen forests		Peats		
Most suitable for grass cultivation in hay and pasture lands. Utilization for vegetables or other crops possible only with irrigation, application of large quantities of mineral and organic fertilizers, and afforestation for the protection against erosion and sandy deposits during floods.	Soils of high fertility. Suitable for vegetables, forage crops and grasses. Intensive utilization for vegetables requires the introduction of perennial grasses into crop rotation, application of organic and mineral—chiefly potassium, but on acid soils also phosphorus—fertilizers and lime.		Soils of high potential fertility. Effective utilization possible only after drainage and application of measures safeguarding the mineralization of organic substances. Especially favorable for vegetable cultivation. Besides potassium and phosphorus fertilizers, the application of copper, boron, and manganese is often needed.		Utilization for all crops requires liming and application of organic and mineral fertilizers.

river bed). The intensification of the sod process can also be a result of reduction of forests by man.

Soils formed as a result of similar changes in the conditions of soil formation we call secondary sodded (or meadowed) podzolic bottom land soils. If the bottom land soils of the gray forest type were subjected to meadowing we name them secondary meadowed bottom land soils of the gray forest type.

We have often found similar sodded and meadowed soils in bottom lands of the Oka and Kl'yazma rivers. However, we must admit that we have always experienced difficulties in differentiating between meadowed podzolic soil and meadowed soil of the gray forest type. New observations and investigations are essential here.

Despite their brevity and general nature, the agricultural-industrial characteristics of bottom land soils cited in our classification confirm the necessity of examining these soils precisely as soil types.

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Methods

SOME CHARACTERISTICS OF THE REACTION BETWEEN SOILS AND FULVIC ACID SOLUTIONS

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IT has been established that a decisive part in podzol formation is played by active organic ubstances; fulvic acids, formed during the deomposition of forest litter under the bioclimatic onditions of the taiga zone (1, 3, 4, 6, 7). Howver, some aspects of the podzol formation procss remain insufficiently explained, in particular, he problem of the part played by fulvic acids n the removal of adsorbed cations from soils.

This article is devoted to an examination of he experimental data obtained by us during a tudy of the removal from soils of exchangeable ations by the action of dark-colored fulvic acid apocrenic acid). Samples were collected of the umus (cultivated) horizon of a clay loam grey orest soil and of the soil-forming parent mateial—a clay deposit. The composition of the adorbed cations of these samples, together with ome of their chemical characteristics, are given n Table 1.

The fulvic acid used in our study was isolated 2) from the B horizon of sod-podzolic soils Katovsk district, Gor'kiy province) and conained 46.15% carbon, 4.23% hydrogen, 46.93% xygen and 2.69% nitrogen, that is, it had the sual elementary composition for dark-colored ulvic acids. The solution of fulvic acid containng 1 mg. dry matter per ml. had a titratable cidity of 15.4 me. per liter, pH 2.53 and the onventional index of the degree of dissociaion—K = 19.4%. The value K was determined rom the data of active acidity (pH) and titratable acidity (potentiometrically up to pH 7), as was done by A. A. Rode in his study of water xtracts of forest litter (5).

In order to obtain comparative data, the desorption process of adsorbed cations from soil nd clay was carried out simultaneously with HCl solution, also at pH 2.53, which corresponds to 3 me. acidity per ml. solution. Thus, the solutions of fulvic acid and HCl used in our study were identical as regards activity of hydrogen ions but differed in values of titratable acidity H. It seemed to us that the equalization of acid solutions according to the activity of hydrogen ions, and not according to titratable acidity, would give a better indication of the part played by fulvic acids in the desorption processes of adsorbed cations.

Experimental details were as follows. Four series of 20 gm. (dry weight) samples of soil and clay were treated in flasks with 200 ml. of solution of one of the acids. They were left for 1, 2 . . . up to 10 days with periodical shaking of the suspensions. The suspensions were filtered at intervals to give clear solutions. Part of each filtrate was used for pH (quinhydrone) and carbon (permanganate oxidation) determinations. Sesquioxides, Ca and Mg, were determined on separate portions of each filtrate after destruction of organic matter by hydrogen peroxide. Sesquioxides were determined gravimetrically, Ca and Mg volumetrically. Hydrochloric acid filtrates, since they contain only traces of soluble organic substances, were analysed without preliminary treatment with H_2O_2.

Table 2 shows the dynamics of the pH value change (of equilibrium solutions). From this we can judge the rate at which equilibrium state in the system is reached.

As shown in Table 2, exchange reactions reach complete equilibrium after different periods of time. Moreover, desorption of adsorbed cations by solutions does not depend as much on the composition and structure of the "adsorbed complex" of soils and clay, as on the nature of the replacing solution. In any case, the individual characteristics of sorbents are shown less clearly than are the chemical characteristics of the acids taking part in exchange reactions. When fulvic acid took part in the exchange, equilibrium was reached only after 7 to 9 days, while in the

TABLE 1

Some chemical characteristics of soil and clay[a]

Samples	Humus content, %	Exchangeable cations, me. (according to Gedroits)		pH (KCl)	Loss on ignition of clay fraction
		Ca	Mg		
Soil	2.51	14.32	2.11	5.35	24.70
Clay	0.19	7.05	1.46	5.42	10.29

[a] For purposes of abbreviation the humus horizon of gray forest soil is called "soil" and the clay deposit "clay".

TABLE 2

Variation of pH of solutions with time

Series of experiment	pH of initial solution	pH of equilibrium solution					
		Days					
		1	3	5	7	9	10
Soil + fulvic acid	2.53	3.76	3.98	4.16	4.27	4.35	4.36
Clay + fulvic acid	"	4.06	4.27	4.42	4.49	4.56	4.61
Soil + HCl	"	4.89	5.63	5.66	—	—	—
Clay + HCl	"	5.37	5.80	5.81	—	—	—

TABLE 3

Desportion of Ca and Mg from soil and clay

Series	Replaced (me. per 100 gm. of sample)		Total Ca + Mg, me.	As % of content in 100 gm. of sample	Ca:Mg
	Ca	Mg			
Soil + fulvic acid	3.31	0.72	4.03	24	4.6
Clay + fulvic acid	2.60	0.75	3.35	18	3.5
Soil + HCl	1.87	0.33	2.20	13	5.7
Clay + HCl	1.71	0.40	2.11	11	4.3

TABLE 4

Carbon and sesquioxide contents of the final fulvic acid and HCl equilibrium solutions

Series	C content of 1 liter of solution, mg.	C content of 1 liter of final equilibrium solution, mg.	C adsorbed by soil & clay as % of initial content	R_2O_3 found in solution (mg. per 100 gm. of soil)
Soil + fulvic acid	461	380	17	22
Clay + fulvic acid	461	213	54	109
Soil + HCl	—	—	—	none
Clay + HCl	—	—	—	traces

soil + HCl or clay + HCl systems, equilibriu was established after 2 to 3 days.

The active acidity of the final equilibrium so lutions for fulvic acid was found to be con siderably greater than for HCl; similarly th solutions had a pH of 4.4 to 4.6 and 5.6 to 5. although, as appears from the data in Table fulvic acid replaces more cations than does HC The lower pH value of fulvic acid equilibriu solutions may be explained by the fact that du ing displacement of Ca and Mg, fulvates of thes cations are formed. Because of the presence these cations a buffer is produced. The buffer of small capacity, since fulvates of calcium an magnesium have relatively small degress of hy drolytic dissociation (8). Further displacemen of cations produces a slow change of pH valu in the buffer mixture being formed. It is pos sible that the small seasonal fluctuations in th active acidity of forest litter of podzolic soil depends on the buffer properties of solutions o fulvic acid and their salts (mainly alkali-eart metals).

Table 3 gives data on the displacement o calcium and magnesium from soil and clay (th contents of these cations in final equilibrium solutions).

From Table 3 it is easy to see that there i a greater yield of cations from soil and cla during the reaction with fulvic acid solution tha during reaction with HCl solution. If the amoun of cations displaced from soil and clay by th HCl solution is approximately equivalent to 70% of the H-ion content in the volume of the re placing solution, the amount of displaced cations is 1½ to 2 times greater during the interactio of these with the solution of fulvic acid, though as regards the activity of hydrogen ions, both working solutions are identical.

We think that the explanation of the observe phenomenon should be sought in the specifi properties of fulvic acid. As in every weakly dissociated acid, a gradual dissociation of hydrogen ions takes place in fulvic acids in proportio as the H-ion is consumed for binding cations Therefore it is natural that, with identical ac tivity of acidity, the fulvic acid solution will re place more adsorbed cations than the HCl solu tion.[1] This circumstance probably has great im portance in the podzol-forming process, since, at comparatively low pH values, (active acidity) the solutions of fulvic acid exert a substantial podzolizing effect on the soil. The fact that the solution of fulvic acid replaces comparatively higher amounts of adsorbed Mg from soil and clay than the HCl solution is also noteworthy. Thus the Ca:Mg ratios for fulvic acid are 4.6 and 3.5, and for HCl 5.7 and 4.3.

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[1] Although as regards titratable acidity the fulvi acid solution was 5 times as concentrated as th HCl solution, its replacing capacity was found t

The specific action of fulvic acids, like that of humic acids, is not limited to the replacement of exchangeable cations. Complex-formation with hydrates of sesquioxides also takes place subsequently; this is not observed during the interaction of soil with the solution of mineral acids of low concentrations. Thus, in addition to Ca and Mg, sesquioxides are invariably found in fulvic acid filtrates, whereas during treatment of soil and clay with 0.003 *n* HCl solution, iron and aluminium do not pass into the filtrates (Table 4). The transfer of iron and Al into the solution takes place at higher concentrations of replacing solutions.

Fulvic acid, reacting with hydrated oxides of iron and aluminium, forms complex compounds —fulvates of the indicated metals—which, depending on the pH of the medium and the degree of dilution of the solutions, either precipitate or remain in solution (3, 9). Under the conditions of our experiment, part of the aluminium and iron fulvates (mainly of aluminium) is adsorbed by soil and clay, as is shown by the difference in carbon content between the original solution of fulvic acid and its final equilibrium solutions. The other part of the aluminium and iron fulvates remains in the solution and consists mainly of iron fulvates. The formation of colloidal precipitates or sesquioxide fulvates begins from the first days of interaction of soil and clay with fulvic acid. This is clear from the results of determination of carbon and sesquioxides contents in the intermediate filtrates. Thus, after a 24-hour reaction of clay with a fulvic acid solution, the filtrate was found to contain 64 mg. of R_2O_3 (per 100 gm. of clay) and its carbon content had decreased by 40%. It follows also from the data in Table 4 that considerably more sesquioxide fulvates were formed from clay almost free from humic substances than from soil.

In conclusion, it should be noted that we used acid solutions of pH 2.53, that is, with a somewhat higher active reaction than is observed in forest litter, but considerably lower than in HCl solutions used in analytical practice for the determination of exchangeable cations in soils.

Conclusions

1. In the podzolic group of humus formation, fulvic acids are one of the factors in the removal of cations from the soil.

2. With small active acidity, fulvic acid solutions displace considerable amounts of cations from soils owing to the passage of the H from a potential into an active state. Magnesium is displaced relatively more readily than calcium.

3. Exchange reactions between fulvic acid solutions and soils' adsorbed cations are complicated by physico-chemical reactions, as a result of which mobile iron and aluminium compounds are formed.

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be only 1½ to 2 times as great as that of the HCl solution.

SEPARATION OF CERTAIN NORTH KAZAKHSTAN SOIL COMPLEXES ON AERIAL PHOTOGRAPHS

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THE territory of North Kazakhstan is characterized by a great diversity of geographical conditions of climate, geological structure, relief (chiefly meso- and microrelief), of distribution of surface and ground waters, erosion, deflation, saline parent material and others. All these influence the nature of the soil complexes. Therefore, the location of complexes and soil combinations correspond to each of the landscapes of North Kazakhstan.

Aerial photographic data have turned out to be of considerable assistance in separating prevailing soil groups and in their study.

The use of photographic plans and aerial photographs in combination with topographic maps makes it possible to separate regions characterized by definite types of complexes. Aerial photographs provide additional information on the nature of meso- and microrelief and geological structure which the ordinary topographical map does not show; they play a decisive role in the formation of soil complexes. These data obtained from large-scale (1:10,000 and 1:25,000) aerial photographs are transferred to a topographical map of a smaller scale (for example, 1:100,000). In this way, a hypsometric map can be compiled on the required scale (1). By analyzing further the pattern of the photographic image, using various techniques, it is possible to fill in the gaps of the map plan with the various soil boundaries and soil complexes. Information obtained about soil cover, acquired from a detailed investigation of one section, can be extended to similar sections of a given landform area with respect to relief and other conditions. Map diagrams combined with photoplans permit a rapid and accurate identification of arable sections.

The most widely distributed landforms were selected for soil cover study in the steppe areas of North Kazakhstan.

In the present article we will deal with the specific nature of landforms on low-relief plains. A section in the Lake Koksengirsor region in the eastern part of Kokchetavskaya region is such an area. From the Borovskiye Mountain massi west of the section to be investigated, elevation decrease, in the east and northeast, from 200 m to 150 m. in the given section. Geomorphologically, the area is very complex and diversified sections of an undulating plain alternate with areas of hilly-mound plain with ridges and isolated barren hills and lake basins.

A schematic, soil-geomorphological map of the indicated territory was compiled by A. S. Preobrazhenskiy in 1955. It was based on the delineation of aerial photographs on a topographic base. A series of geomorphological sections are distinguished on this map: low-hilled, watershed plains on Paleozoic rocks, slightly inclined plains combined with eroded and depressed relief; deluvial, sloping plains on the site of an old lake bed, with deluvial deposits on tertiary outcrops; lake basins with well-developed terraces; remains of level, ancient lake terraces with old clay loam and sandy loam deposits; regions of broad, alluvial-lake plains. In spite of such a variety of relief forms, they are all characterized by low elevations: relative relief here does not exceed 5 to 10 m., more often varying between 2.5 to 3 meters.

The soil-generating material consists of frequent outcrops of Paleozoic strata, the deluvia and eluvia of these rocks, weathered crust, loess clay-loams, and accumulated lake deposits.

Complexity of the relief and geological structure make for great diversity in soil cover, composed as it is of various soil combinations and complexes characteristic for these or other geomorphological areas.

We made a study of certain soil complexes in the field and of the nature of their representation on aerial photographs on a scale of 1:30,000, but partly on a scale of 1:10,000. The survey was made, almost in a single period, in the middle of July. We will deal with the following characteristics: 1) the soil complexes of sections with depressed relief; 2) lithogenic complexes; and 3) erosion complexes of the slopes.

omplexes of Sections with Depressed Relief

Depressed mesorelief is the most characteristic eature of watershed plains. It is distinguished y the depth of the depressions, their size, form, ocation and by the nature of their vegetation, nd also by the type of resulting soil comlexes. These differences result from a series of actors: depth of the deposit and character of he bedrock, thickness of the mantle, drainage attern, and so on. Three types of depressed reief clearly stand out in the section: depressed elief on watershed plains with deposits close to utcrops; depressed relief on loess deposits of onsiderable thickness; shallow, depressed reief.

The characteristic soil complexes of depressed elief are steppe complexes on the upper slopes, nd meadow complexes in the depressions and n their slopes. An example of a depressed, waershed section is the low plain between the holaksor and Koksengirsos Lakes, which ocurs on Silurian rocks. There are a great number f depressions on the plain. Singly or connected n chains, they extend over extensive outcrops n a southwest to northeast direction. They ocupy almost 16% of the area here, their depth is .5 to 2 m. Shallow depressions contain meadow egetation, the large ones contain swamps.

The photographic image of the section is comosed of complex combinations of light-grey, rey and dark-grey tones (Fig. 1). The lightrey tone represents the highest sections beween depressions with sparse vegetation of escue, wormwood and feather grass on low-hunus, slightly saline chernozems, with occasional etritus. The grey tone refers to the more grassy ections with a fescue-feather grass vegetation n carbonate, medium-humus chernozems. The nottled, micro-patterns on the photographic mage denote rapid change of the vegetation roupings, and consequently, a change of soils rom thin, solonetz-like chernozems to thicker on-solonetz-like chernozems.

Along the slopes of the depressions the prelominant tone is grey and more uniform. It efers to medium thick, medium-humus chernoems under poor grass varieties and fescueeather grass vegetation. Thickness of the humus oil horizon reaches 22 to 25 cm. An accunulation of carbonates is observed at this same lepth. The whole profile is of a rather coarse texture. Frequently, meadow-chernozem, meadow and solodi soils occur on the lower parts of the slopes and in shallow depressions where there is increased moisture, and under meadow vegetation of *Bromus inermis*, *Agropirum repens*, *Galium verum* and others. They have a better developed humus horizon (up to 35 to 40 cm.), a lower carbonate horizon, and a horizon of gypsum agglomerate. The bottoms of the deepest depressions are covered by meadow-bog and gleybog soils beneath meadow-bog and sedge-bog vegetation, which is clearly defined on the photographs.

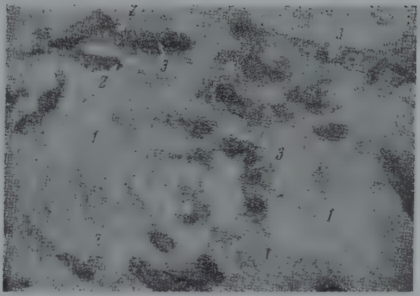

FIG. 1.—Aerial photograph on a 1:10,000 scale. Soil complexes of a section with depressed mesorelief on thin mantle deposits. 1—complex of thin, slightly solonetz-like chernozems and medium-humus, carbonate chernozems; 2—complex of meadow-cheronzem, meadow, solodi soils; 3—meadow-bog and gley-bog soils.

Meadow-chernozems can not be distinguished successfully from meadow or meadow-solodi soils on 1:10,000 or even the larger-scaled 1:30,000 photographs since all of them show up as a dark-grey tone. However, on the basis of field observation data, one can conclude that in the marginal portions of the dark-grey outlines, meadow chernozem soils predominate changing to meadow soils and then to meadow solodi soils toward the center of the depressions.

All these soils comprise the zone of the depressed complex as distinguished from the diffused (scattered) complex of the uplands.

Thus, the steppe complexes of the uplands are represented on the photographs by a lighter tone—reflecting the lack of moisture, especially on the micro-elevations, certain outwashing and erosion of silt and an insignificant vegetation cover. On the other hand, the meadow complexes show up as a darker tone on the photo-

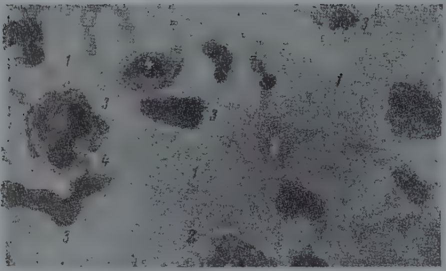

FIG. 2.—Aerial photograph on a 1:10,000 scale. Soil complexes of a section with depressed relief on a thick mantle of clay loam. 1—complex solonetz-like and non-solonetz chernozems; 2—meadow-chernozem and meadow soils; 3—solodi; 4—gley-bog soils.

graphic image—reflecting an upland surface, soil moisture and dense mesophytic vegetation. The combinations of steppe and meadow complexes are the characteristic soil combinations of an undulating, depressed meso-relief. Such combinations create a specific pattern and are easily distinguished from others on the photoplan.

The second example of depressed meso-relief on the watershed plains is the section north of Lake Sholaksor, some distance from the one described (Fig. 2). Here, the depressions have no definite alignment; their shape is usually circular, 1.5 to 2.5 m. in depth, and have steep slopes. The largest depressions serve as catch basins for the surrounding sections and are generally covered with swamps and ringed by willows. Many depressions contain surface water. Inter-connecting depressions contain stria which are filled with meadow vegetation. The slopes of the depressions and these stria make up a single system, having approximately the same moisture content as meadow-chernozem and meadow soils. The area occupied by this complex of meadow, meadow-chernozem and meadow solodi soils comprises 20 to 25% of the entire section. The area occupied by meadow-bog and bog soils can be assumed to equal the total area of the depressions, since the latter are almost all swamped.

The same complex of soils is as characteristic of the areas between depressions as for the section previously described. Their photographic images are also similar. It is only necessary to note that the striped micropattern corresponding to the strike of the bedrock and peculiar to the first section is less well-defined here, and can be detected only in certain places. This is explained by the greater thickness of mantle deposits.

A specific pattern on the photographic imag is characteristic for the third type of depresse relief—a shallow depression on a thicker laye of fine-grained, loess-like deposit. Sizes of th depressions here are insignificant; depths do no exceed one meter and, on the average, measur 0.3 to 0.5 m. Depressions number 20 to 50 pe 1 km²; their total area makes up about 25% o the entire section.

Because of the insignificant depth of the depressions, meadow-bog, bog and partly meadow solodi soils are almost non-existent. The chie components of the soil complexes here are low humus chernozems, clay loams, often with solonetz-like indications on the uplands; an meadow-chernozem and meadow soils in the depressions with meadow vegetation. Individua depressions contain swamps; some, however, ar covered by solodi under birch stands. Some salinity of the soils is also characteristic—the appearance of solonchak and solonetz around th depressions.

All the types of depressed landforms describe are not suitable for cultivation. Because of th abundance of large depressions, and the grea quantity of infertile soils, the first two (meadow solodi, meadow-bog, gley-bog soils, as well a weakly-developed skeletal soils) hinder ful mechanization of cultivation of the area. Th third type is also unsuitable because of th numerous depressions. The latter, however, do not hinder full cultivation but create an undesirable crop diversification. In addition, saline soils are mixed in here. Aerial photographs provide a means for rapid and unmistakable determination of territories of such groups, and thereby guard against attempts to cultivate them.

Lithogenic Soil Complexes. Soil complexes possess a specific character when they originate from rocks of diverse lithologic and chemica content; outcropping either on the surface o close to it under a thin mantle. We consider such complexes as lithogenic.

Because of a varying degree of denudation i outcropping strata of varying lithologic content microrelief ridges are developed in the harde rocks, and microrelief depressions between the ridges in less resistant rocks. Depending on the composition of the rocks, the ridges sometime attain significant elevations (1.5 to 2 m.), bu more often, no more than 0.3 to 0.5 m. Outcroppings and their detritus are observed on the tops of the ridges and on the slopes of the bedrock. The fine-grained sediments are washed away into the hollows between the ridges, are well-moistened and covered by a more dense vegetation.

Such a microrelief is represented on the aerial photographs by a unique, striped pattern of alternating light-grey, grey and dark-grey bands which are the photographic image of strata of different lithologic content. On the investigated section, this pattern is observed on the terraces of Lake Sholaksor. The striped pattern of the photographic image is clearly visible on the 1:10,000 and 1:30,000 scale photographs (Fig. 3).

The lithogenic soil complex is composed of solonetz on the summits of the ridges and on their slopes, and of medium thick sandy loams and coarse clay loam chernozems in the hollows between the ridges.

The section on the summit of the ridge, one meter in height, under a fescue-wormwood vegetation with a section of feather grass, appears here as slightly saline, slightly solonetz with a columnar solonetz structure, which effervesces with HCl for 25 cm. The proximity of the bedrock is evidenced by the abundance of detritus and rock fragments both in the soil and on the surface, as well as by the color of the soil profile horizons. Between 25 to 30 cm., the soil is a greenish color (color of argillite). Solonetz characteristics are best portrayed on the summits of the ridges because of the increase in temperature. They are less obvious along the slopes but are still significant. Low humus content, lack of moisture, abundance of detritus and insignificance of the vegetation cover produce high spectral intensity of the solonetz, and they are therefore represented on the photograph by a light-grey tone. There is often a mottled micropattern on the light-grey tone which corresponds to the micro-complexes of solonetz and solonetz-like chernozems. The cover here is wormwood-feather grass and feather grass. The wormwood-feather grass patches of vegetation are represented by the lighter tone and the feather grass by the darker.

Medium humus, sandy loam and coarseclay loam chernozems occur in the hollows between the ridges, covered by fescue-feather grass vegetation with an insignificant variety of grasses. Seventy to eighty percent of the vegetation cover is projected. Detritus and rock fragments are scarce on the surface and absent in the soil. The thickness of the full humus horizon reaches 30 cm.; projections of humus penetrate from 50 to 60 cm. There is continuous effervescence with hydrochloric acid from 26 to 30 cm. Lower horizons of the soil profile contain traces of former excessive moisture and anaerobic processes in the form of gleying. The grey tone of the photographic image is darker than that of the elevated sections. This is due to a significant amount of moisture in the soils, comparatively high humus content and, chiefly, by the high projection of the cover and deep color of the vegetation.

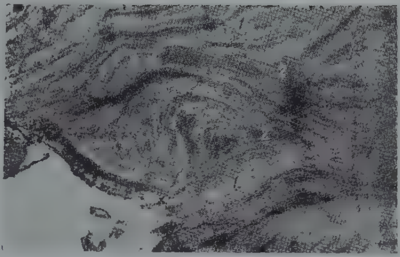

FIG. 3.—Aerial photograph on a 1:30,000 scale. Lithogenic soil complex. 1—solonetz; 2—medium-thick sandy loam and coarse clay loam chernozems.

Characteristic of the lowland chernozems is their association with numerous burrows and gopher runs with dense xerophytic sod grass. Patches of xerophytic sod grass are distinguished in this locality by a dark color; on the photograph they are represented by dark points which are scattered throughout the dark-grey tone and very infrequently in the light-grey tone. Thus, they are unique indicators of chernozems.

The lithogenic complex of the watershed plain associated with the highly dislocated tertiary bedrock displays a mixed pattern on the photographic image. This pattern reflects the peculiarities in the structure of the bedrock which is visible through the thin deposits of the fine-grained material.

The microrelief has a soil complex of eroded skeletal soils on the small ridges and isolated hills covered by thin, xerophytic vegetation and low humus contents of chernozems developing on fine-grained deposits covered with fescue-wormwood vegetation. This microrelief corre-

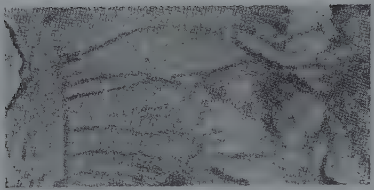

FIG. 4.—Aerial photograph on a 1:30,000 scale. Erosional soil complex on the gentle slopes of a lake basin. 1—thick, high-humus, clay loam chernozems; 2—meadow-chernozems and alluvium of underdeveloped dark-colored soils.

sponds to the strike of strata of varying hardness. The bedrock exerts the basic influence on the photographic image here. Its occurrence close to the surface leads to a decrease in the thickness of the soil layer; its low humus content, abundance of detritus on the surface and sparse grass cover combine to increase the reflecting capacity.

The lithogenic soil complexes are well distributed over the given section. They are not very favorable to cultivation, however, because of the detritus and solonetz-like condition of the greater part of the soil, and because of the irregularity of the relief in some places. It is not difficult to distinguish them by means of aerial photography.

Erosion Complexes. Erosion complexes on the slopes of the lake basins and watershed plains are usually of two types and represented by zonal chernozems or solonetz, and by dark-colored soils of run-off channels and of stria. The photographic image of the eroded sections exhibits a specific pattern formed by dark-grey stripes in grey and light-grey tones. Depending on the character and steepness of the slopes these stripes are straight-lined or winding. Whereever the greatest erosion of fine sediments is observed, the tone of the photographic image is lighter than in places of its greatest accumulation. Commonly, the eroded soil complexes in the sections between the stria are less thick, weakly-developed with the presence of detritus; however, in the soils of stria and run-off channels they are very thick with humus and moisture. The adaptation of various vegetation groupings to these elements creates a different character on their photographic image.

Several types of erosion relief can be distinguished on the section investigated: slightly eroded slopes with stria; greatly eroded slopes with gullies, run-off channels and stria; and in various degrees, the eroded, asymmetrical slope of the watershed ridge.

Figure 4 gives a representation of the erosion complex of the gently sloping third terrace of Lake Shotsor. Mantle deposits on the slope of the lake basin are loess, clay loams with numerous marmot burrows and runs serving as unique indicator of their presence. Erosion here is expressed by a series of shallow (30 to 50 cm.) stria distributed across the slopes. The stria are distinguished with difficulty on the spot, but are clearly seen on aerial photographs.

Components of the soil complex of the slope are thick, high humus content clay loams interspersed with a humus horizon and a deep carbonate horizon. These soils are distributed under poor grass varieties and feather grass, with about 80% of the cover exposed. The grasses grow as high as 50 to 70 cm. They appear as an even grey tone on the photograph, with scattered white patches of marmot burrows and runs. Soils with greater moisture are adapted to the stria—meadow chernozems and alluvial, underdeveloped, dark-colored soils. Vegetation on the stria are distinguished by the presence of a considerable quantity of mesophyte species and great projection of the cover (100%).

The erosion complex of the eroded, drained slope of Koksengirsor (Fig. 5) is somewhat distinctive in the pattern on the photographic image. The large area of the catch basin and significant steepness of the slope aid in the development here of wide and deep (up to one meter) gullies, which drain into the lake, and of numerous secondary, sloping troughs and stria, the latter being branches of these gullies.

Fine deposits are observed in the stria and channels of intermittent streams. They are abundantly moist in the spring and summer after

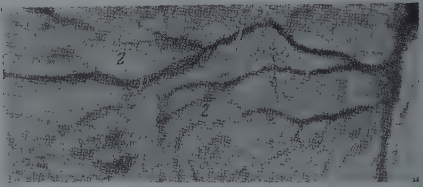

FIG. 5.—Aerial photograph on a 1:30,000 scale. Erosional soil complex on the steep slopes of a lake basin. 1—alluvium of underdeveloped and dark-colored soils; 2—shallow-columnar and deep-columnar solonetz.

ains. Alluvial, underdeveloped chernozem soils ccur here under dense, tall grass varieties and eather grass vegetation, and appear as a dark ackground on the photographic image of stria nd gullies. Shallow columnar solonetz beneath hin feather grass, and fescue-wormwood vegeation are developed on the sections between the un-off troughs; thick, columnar solonetz soils ccur under wormwood-fescue and feather grass vith a section of Linosyris villosa. Close to the ake the wormwood portion of the vegetation over decreases, conforming to a decrease in the olonetz development of the soils. The solonetz levelopment also decreases close to the run-off hannels.

The photographic image of the erosion netvork contains a system of winding and blending lark-grey strips. The pattern of the photoraphic image of the slope is complicated by he influence of bedrock covered by a thin layer f eluvia and deluvia, and by accumulated lake leposits on the lower part of the slope.[1] Aerial hotographs on a scale 1:30,000 and 1:10,000 nake possible the easy separation of the soils of tria and channels of intermittent streams from he solonetz of the sections between the stria.

The section of the watershed slopes located omewhat north of Lake Koksengirsor can serve s one example of the erosion complex.

The steeper northern slope of the ridge is inersected by a thick network of stria gradually roadening and changing into basins. Ridges rom 1 to 1.5 m. high with outcroppings of bedock are located between the stria. Eroded, trongly solonetz-like chernozems are developed n the ridges with a thin fescue-wormwood egetation cover.

In the stria beneath grass varieties and feather rass vegetation, there are deposits of underleveloped chernozems, and on the lower portions f the basin slopes there are meadow-chernozem oils below grass varieties and meadow vegetaion. The central sections of the basins are ocupied by peat solodi and gley-bog solodi soils.

On the steeper southern slope of the ridge, the tria are straighter and oriented in a southwest lirection. The components of the soil complex ere are weakly-developed, skeletal solonetz-like oils in sections between the stria, and underleveloped solonetz-like chernozems on the stria. The pattern of the photographic image of the given section also has its own peculiarities. (Fig. 6).

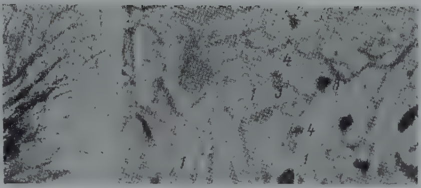

FIG. 6.—Aerial photograph on a 1:30,000 scale. Erosional soil complex on a slope of the watershed ridge. 1—eroded, strongly-solonetz-like chernozems; 2—alluvium of underdeveloped cheronzems; 3—meadow-chernozem soils; 4—peat-solodi and gley-bog soils.

Conclusions

1. The section investigated in North Kazakhstan is characterized by a complex soil cover of low-hilled plains. The soil cover here is represented by different complexes—basin, lithogenic and eroded.

2. The soil complexes named are clearly distinguished on aerial photographs, owing to the specific pattern of the photographic image and by a series of direct and indirect signs (relief, rocks, vegetation, tone and pattern of the arable land).

On the aerial photographs individual components of the soil complexes—chernozems, meadow soils, solodi, bog soils, solonchaks, xeromorphic soils on the hilltops and slopes also can often be detected.

3. The separation of the soil complexes and their components on aerial photographs makes it possible to determine those sections of suitable plowland by distinguishing sections unsuitable for cultivation.

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[1] The straight lines in the pattern correspond to ines of tectonic fractures.

EFFECT OF FOREST LITTERS ON CHEMICAL PROPERTIES OF SOILS IN THE SOUTHERN TAIGA SUBZONE

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In studying the cycle of ash elements in woody plants, we cannot disregard the role of forest litters. We should also observe the transformation of organic substances in forest litters, because certain products of this transformation take an active part in podzol formation.

The effect of decomposition of forest litters on soil formation depends, as stated in investigations by Kravkov (5), on the kind and rate of decomposition in organic substances, on the amount of cations stored in forest litters, and on the rate of their liberation and leaching in the course of decomposition. The litters of conifer plantations have a slow decomposition rate of organic substances and a low cation content; here the products of decomposition are acid, unstable. The action of a leaching water regime and of periodic anaerobiosis with a predominantly acid reaction produces a podzolic horizon. In deciduous forests, the circumstances are different. Here, the supply of cations is sufficient to assure the neutralization of organic acids. For this reason, a replacement of conifers growing on podzolic soils by a planting of deciduous trees on a grassy ground cover brings about an accumulation of organic substances and ash elements in the upper soil stratum (9, 6).

This paper presents results of our studies on forest litters and soils in coniferous and deciduous forests. The field work was done at the Zvenigorodsk MGU biological station, Moscow district. In character of landscape, this territory belongs to the southern taiga subzone. We selected a stand of fir with green moss (*Polytrichum strictum*) as ground cover for the main subject of our study. For comparison, we used a birch stand with grass and fern (*Pteridium*) as forest floor.

The first test area was laid out on a leveled reservoir in a fir forest growing on green moss. The composition of the planting was 10 fir + 1 birch; site quality I; 83 year old stand; stand density, 0.1. Numerous fir seedlings covered the area; undergrowth and saplings were absent. The mossy cover consisted chiefly of *Pleurozium Schroeberi* and *Hylocomium proliferum*. The grass cover consisted of solitary specimens o *Ramischia* (*Ramischia secunda*), blackberry *Vaccinium myrtillus, Rubus saxatilis*, and bedstraw (*Galium boreale*). The second test area was located in a similar soil profile in a birch forest on a mixture of *Pteridium* fern an grasses. Planting composition was 7 birch, 3 pine + fir; site quality III; 67 year old stand; stand density, 1.0. An undergrowth of numerous young firs 3 to 5 meters high covered this area. The grassy ground cover was thin; under the young firs it was absent altogether. There was a grea variety of gramineous plants, *Calamagrostis epigeios, Poa nemoralis*; occasionally fern (*Pteridium aquilinum*), *Veronica officinalis*, bilberry (*Vaccinium vitis-idaca*), blueberry (*Vaccinium myrtillus*); rarely *Aegopodium podagraria, Orobus vernus, Glechoma hederacea, Majantemum bifolium* and others.

The top layer of the test areas consisted o slightly sodded, strongly podzolic fine clay loams developed on a coarse sandy fluvio-glacial deposit. A more detailed description of test areas can be found in publications by Smirnova (11 12). The total annual litter fall in the fir stand was about 3.2 metric tons per hectare; in the birch stand over *Pteridium* fern and grasses, the mass weight of the same was about 2.8 metric tons per hectare (12). The weight of the total accumulation of forest litter was considerable for both plots: 21.2 metric tons per hectare for firs on green moss, and 18 metric tons per hectare for birches with a ground cover of grasses and *Pteridium* fern (Table 1). Separate estimates by layers for each mass of forest litter showed that both the thickness and the firmness of packing of the horizons increased with increasing depth. By far the greater mass of litter—about 10 metric tons per hectare—was concentrated in A_0'''. The reason for this was the higher mineral content of inclusions. Owing to the greater annual fall of needles and, above all, owing to the slower rate of decomposition, the mass of litter from firs with green moss ground cover was heavier than that from the birch planting.

In literature there has been frequent mention f the high ash content of the lower horizons of orest litters. This is because, first, the ash con- ent of forest litters actually increases in the ourse of mineralization of organic matter, and econdly, because the lower horizons of litters ontain a large admixture of soil (14, 15). It is dvisable to separate forest litters into their omponents, the organic and the mineral sub- tances, and the latter, in their turn, into ash nd mineral inclusions (Table 2).

These data show that the process of minerali- ation of forest litters tends to increase their ash ontent. The increase is slight because part of e ash elements liberated in the course of de- omposition of the leaves or needles is leached ut, another part is absorbed by plants. At the me time, the content of mineral inclusions ows a striking increase from the upper to the wer strata of litter.

The birch litter has a somewhat greater ash ontent, to correspond with greater ash content i its fallen leaves. Because birch leaves decom- ose more rapidly and because there is more soil dmixture in the litter, the content of mineral iclusions is higher here than in the litter from e fir stand with green moss ground cover. The mount of soil admixture in forest litters is di- ectly related to the activity of animals that in- abit them. Thus the composition of litters in a r-forest biocenosis is partly related to the pov- rty and few species of fauna; and the rapid ineralization and the fine texture of litter par- icles in deciduous forests is associated with the ealth and variety of its animal life (1, 9). hanges in the proportions of basic components at take place in the process of mineralization f forest litters go hand-in-hand with changes i their organic makeup.

A comparative analysis of organic matter in e different horizons of forest litters and forest il (Table 3) discloses certain regularities in e transformation of plant residue[1]. Organic atter in forest litters is represented by two enetically different groups of compounds. The rst group consists of compounds that are the roducts of trees (cellulose, lignin and others); the second is made up of synthesized products formed in the decomposition of plant remains (humic acids and so on). There is a decrease from the upper layers of litter toward the lower in the content of compounds of the first type, and a simultaneous increase in content of humus-like substances. At the same time, there is a general decrease in content of organic matter. In the process of decomposition of the fallen litter material, the content of compounds belonging to the first group—lignin, cellulose and hemicellulose—decreases abruptly while the bitumen content drops more gradually.

TABLE 1

Amounts of forest litter accumulated under forests of fir with green moss (Polytrichum commune L.) ground cover and birch with a mixture of Pteridium fern and grass ground cover. Data given in metric tons per hectare of substance that had been dried at 70 to 75°

Horizon	Plantation	
	Fir	Birch
A_0'	2.89	1.06
A_0''	8.23	6.07
A_0'''	10.13	10.86
Total amount of litter	21.25	17.99

TABLE 2

Composition of forest litters under firs with Polytrichum moss as ground cover and birches with Pteridium fern and a grass mixture as ground cover. Figures are given for different horizons, in % of substance dried at 70 to 75°

Horizon	Plantation					
	Fir			Birch		
	Mineral portion		Organic portion	Mineral portion		Organic portion
	Ash	Mineral inclusions[a]		Ash	Mineral inclusions	
Litter	3.16	0.27	96.57	not determined		
A_0'	3.14	4.98	91.88	3.19	6.53	90.28
A_0''	3.61	16.12	80.27	3.98	17.83	78.19
A_0'''	4.17	29.13	66.70	4.53	31.68	63.79

[a] Mineral inclusions were selected with the aid of a binocular microscope from the ashes of an ignited sample.

We also want to point out some differences in the composition of organic matter in litters from the two types of forest investigated. They are mainly as follows: 1) fir forest litters have a greater content of bitumens and water-soluble

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[1] Data describing the group composition of hu- ic substances in litters are somewhat provisory ecause the method used had been worked out for ineral soil horizons. However, these data give ome idea of the kind and tendency of decompo- tion processes in the organic matter of different rest plantations.

TABLE 3

Chemical composition of organic matter in litters and soils of fir stands with Polytrichum (green) mo ground cover and birch stands with Pteridium fern and grass ground cover[a]*, in percent of C of organic matter*

Plantation	Soil horizon	Depth, cm.	Bitumens	Hemi-cellulose	Cellulose	Lignin	Humic acids	Fulvic acids	Water-soluble substances	Non-soluble residue	C of humic acids / C of fulvic acids	Humus, aft Gustavson
Fir	A_0'	0–3	11.8	12.6	25.7	27.3	2.9	4.3	3.3	8.6	0.6	not det
	A_0''		10.4	7.3	18.4	21.9	6.4	13.7	2.4	16.4	0.5	”
	A_0'''		10.5	6.8	16.3	19.3	7.2	15.2	1.5	18.5	0.5	”
	A_1	3–8	6.5	5.3	7.9	2.3	18.6	29.0	0.8	26.7	0.7	2.26
	A_2	25–35	not determined									0.28
Birch	A_0'	0–3	9.9	14.5	26.1	27.7	2.6	5.3	2.8	7.8	0.5	not det
	A_0''		9.3	9.7	19.0	20.1	7.5	14.0	2.2	16.0	0.5	”
	A_0'''		8.4	6.3	16.6	18.7	8.5	14.3	1.0	17.9	0.6	”
	A_1	3–8	5.5	6.1	8.6	1.8	23.3	26.6	0.5	24.5	0.9	3.59
	A_2	25–35	not determined									0.21

[a] Determinations of hemicellulose, cellulose and lignin were made following the method describe by K. K. Gedroits in supplementary notes to his book, Selected Works, Vol. 2, Chemical Analysis c Soils, "Description of new methods for soil analysis", p. 468. Determinations of group composition c humus were made after the method of I. V. Tyurin, and determinations of water-soluble substance after the method by S. S. Dragunov.

[b] In percent of soil that had been dried at 70 to 75°.

compounds throughout the entire profile; 2) they have a lower content of hemicellulose and cellulose in the A_0' and A_0'' horizons; 3) a lower content of humic acids and a larger content of fulvic acids are found in the lowermost strata, so that the C-ratio of humic acids to the C of fulvic acids is narrowed down. The composition of organic matter in the soil differs from that in the litters: it has a smaller number of compounds belonging to the first group and a predominance of humus.

In the soil under conifer plantations, the accumulation of fulvic acids and compounds that make up the non-soluble remainder goes on at a somewhat faster rate. On the other hand, the accumulation of humic acids is much slower. This is characteristic of forest soils where the development of a special group of microorganisms produces a "coarse" humus with a low content of humic acids (9, 6). The predominance of fulvic acids over humic acids prevents any considerable accumulation of humus in the soil. For this reason, its content in horizon A_1 of the soil, under the fir stands, is only 2.2%. A higher content of humic acids and also of alkaline soil cations under the birch stands accounts for a larger accumulation of humus here—as much as 3.6%.

The changes in chemical composition of organic matter described here are associated with considerable changes in mineral composition (ash + mineral inclusions). The greater mas (70 to 80%) of mineral matter in forest litter. consists of four elements: Si, Ca, Al and Mg the remaining 20 to 30% are Fe, K, P, and S The chemical elements tend to divide into tw groups, each of which behaves differently in th decomposition process of the organic mass o litter: Si, Al and Fe tend to accumulate whil the elements Ca, Mg, P, K and S decrease (Table 4). We realize that in the lower litter horizons, the increased content of Si, Al and F ma be due to increase in content of mineral inclusions (Table 2). However, the course of change in ash content alone reflects the same tendenc (2).

Further comparison of the chemical composition of the litter from fir forest with green mos (*Polytrichum*) ground cover with that of soi and parent material shows that the content o elements of the first group is low in the litte and much higher in the soil and in the paren material. A maximum content of Si is found i horizons A_2; a maximum of Al and Fe occurs i horizon B. The distribution of elements in th second group is different. There is a gradual decrease in content of Ca, Mg, P, K and S from forest litter toward soil. The decrease in K i most rapid. Horizon A_2 contains less of these elements than all the other horizons. In the paren material, there is again an increase in content o K and Mg, apparently due to less weathering o

TABLE 4

ata on total analysis of forest litters and soils in fir stands with green moss (Polytrichum) ground cover and birch stands with Pteridium fern and grasses ground cover[a]*, in percent of substance dried at 70 to 75°*

Plantation	Horizon	Depth, cm.	Si	Al	Fe	Ca	Mg	K	S	P	N
Fir	Litter		0.71	0.15	0.03	1.26	0.41	0.26	0.16	0.18	0.91
	A'_0	0–3	3.01	0.32	0.14	1.23	0.31	0.24	0.14	0.13	1.17
	A''_0		8.66	0.58	0.22	1.18	0.30	0.13	0.11	0.08	1.45
	A'''_0		15.23	1.09	0.35	0.76	0.30	0.09	0.09	0.08	1.32
	A_1	3–8	39.91	2.89	1.33	0.47	0.15	0.09	0.09	0.07	0.13
	A_2	25–35	42.78	2.84	1.18	0.33	0.08	0.07	0.02	0.01	0.05
	B	60–70	41.96	3.57	1.44	0.41	0.11	0.11	0.05	0.03	n.d.[b]
	C	110–120	42.09	3.41	2.23	0.44	0.22	0.39	0.06	0.03	"
Birch	A'_0	0–3	3.36	0.43	0.22	1.36	0.32	0.31	0.21	0.13	1.37
	A''_0		8.89	0.48	0.38	1.38	0.32	0.18	0.21	0.21	1.66
	A'''_0		15.84	1.26	0.47	1.25	0.27	0.05	0.17	0.42	1.18
	A_1	3–8	39.03	3.11	1.08	0.61	0.18	0.13	0.14	0.10	0.18
	A_2	25–35	42.61	3.02	0.92	0.46	0.12	0.09	0.02	0.02	0.09
	B	60–70	41.52	3.05	2.06	0.37	0.14	0.19	0.07	0.04	n.d.
	C	92–102	41.89	3.72	2.57	0.38	0.19	0.23	0.06	0.04	"

[a] The data on total analysis of litters were obtained by determining the composition of ash and that f mineral inclusions. The weight of elements thus obtained was added together, and its ratio to a weight f litter previously dried at 70 to 75° was estimated (without preliminary selection of mineral inclu-ons).

[b] Not determined.

ne minerals. The P and S are low over the en-re profile of the soils examined, but are clearly resent in the forest litter.

As the mineralization proceeds in the fallen aves or needles, there is first an increase, then decrease in the amount of N. The N content the soil is low, corresponding with its low umus content. Therefore, forest litter acts as accumulator of the important nutritive ele-ent, N.

The profile of forest soils in the birch forest ith *Pteridium* and grass mixture ground cover as its special features. Its content of all the ements is higher than in the litter under the r stands with green moss ground cover. The ost outstanding feature is the total amount of a, Mg, K, S and P, also of N in the humus orizon. Thus the higher accumulation of nutri-ve elements in the soil below this plantation is ue to the richer content of chemical substances the birch forest litter. This conclusion is in eneral agreement with the results of investiga-ons by other authors (9).

Studies by Pronievich (8) have shown that the tter of different tree species has an acid reac-on. The litter of conifers is more acid than that deciduous trees; and of the conifers, the lit-r of fir needles contains the most acid. Accord-g to Zaitsev (4), the litters of firs are the most cid, those of pine less acid; under plantations deciduous trees, the reaction of litters is at times close to neutral. Detailed studies by Stepanov (13) have shown that the active acidity of forest litter changes in the course of decomposition of the organic matter it contains; also that it increases in the lower horizons. Rode (10) found considerable activity in the acid products of decomposition of forest litters under conifers. According to our data (Table 5), the litter of firs with *Polytrichum* moss ground cover was the more acid of the two[2]. This is because the content of cations is lower in the fallen matter of firs than in birch litter (see data on cation exchange). The hydrolytic acidity is also higher here. Hydrolytic acidity increases from the upper horizons of litters downward, reaching a maximum of 40.75 mg-eq. in A_0'''. Exchange acidity is also greatest in litters of fir plantations. It increases from horizon A_0' to A_0''. Its content of mobile Al is notably large. The degree of saturation decreases toward the lower horizons and the exchange capacity is lowered.

Under birch, the litters contain more exchangeable cations than under fir stands and their cation exchange capacity is higher. The greater part of the total amount of exchangeable

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[2] The use of soil methods in analysis of litters is provisory because resulting descriptions for soils and litters are not identical. Judging by literature data, these methods are being used increasingly in the study of various organogenic bases, such as peats and litters (7, 3 and others).

TABLE 5

Physicochemical description of soils and litters under stands of fir with green moss (Polytrichum commune L.) ground cover and birch with Pterdium fern and grasses ground cover

Plantation	Horizon	Depth, cm.	pH		Hydrolytic acidity, me. per 100 gm. of soil	Exchangeable cations			Exchange acidity			Exchange capacity	Degree of saturation
						me. per 100 gm. of soil							
			Water	Salt		Ca^{++}	Mg^{++}	Total	Al^{+++}	H^+	Total		
Fir	A_0'	0–3	5.12	4.61	19.02	41.45	4.73	46.18	4.26	4.08	8.34	54.52	7
	A_0''		4.87	4.27	30.31	31.24	3.41	34.65	7.14	5.69	12.83	47.48	5
	A_0'''		4.65	3.84	40.75	23.67	2.86	26.53	5.52	4.92	10.44	36.97	3
	A_1	3–8	4.53	3.72	4.69	1.74	0.61	2.35	1.83	1.45	3.28	5.63	4
	A_2	25–35	4.31	3.29	2.79	0.59	0.48	1.07	0.92	1.32	2.24	3.31	3
	B	60–70	5.10	4.18	2.35	1.26	0.64	1.90	0.86	0.12	0.98	2.88	6
Birch	A_0'	0–3	5.93	5.10	14.37	56.20	7.29	63.49	2.67	1.59	4.26	67.75	8
	A_0''		5.71	4.92	26.12	42.61	6.23	48.84	3.04	1.88	4.92	53.26	6
	A_0'''		5.68	4.65	31.68	38.75	5.42	44.17	2.81	1.34	4.20	48.37	5
	A_1	3–8	4.78	3.86	6.91	3.24	0.97	4.21	0.49	1.94	2.43	6.64	6
	A_2	25–35	4.49	3.58	3.18	1.13	0.71	1.84	0.66	0.92	1.58	3.42	5
	B	60–70	5.32	4.56	2.37	1.28	0.65	1.93	0.45	0.87	1.32	3.25	6

cations is represented by calcium; the content of exchangeable Al and H is lower. The upper litter horizons are richest in adsorbed cations. Here the degree of cation saturation is very high. It decreases in the downward direction of the litter profile. Changes in amount of hydrolytic acidity are of the opposite kind here and maximum figures are reached in the lower horizons.

A comparison of the soils of the two plantations shows that the soils under the birch stand with fern and grass mixture ground cover are characterized by a lower acidity—active, exchange and hydrolytic. They also contain a greater sum of exchange cations in the humus horizon.

Cation saturation in soil is also higher in birch stand than in fir stand.

All the data studied offer convincing proof of the importance of quality of forest litter in the formation of soils of the podzol series.

Conclusions

1. The chemical composition of organic matter in forest litters and podzolic soils of the southern taiga subzone differs depending on the type of forest plantations. Under fir stand with green moss (*Polytrichum*) ground cover, the soil's content of lignin, bitumens, water-soluble substances and fulvic acids is greater than under a birch stand with grass and *Pteridium* fern ground cover; the content of hemicellulose, cell lose and humic acids is less.

2. The mineralization process in forest litte under both types of plantations decreases th content of cellulose, lignin, hemicellulose an bitumens, and increases the content of humu products from decomposing plant remains.

3. A greater accumulation of humus in th humus soil horizon takes place under the cove of deciduous trees. Here, too, some increase observed in the content of ash elements an nitrogen; and an increase in cation exchang capacity and their amounts are also noted.

4. In the course of decomposition of organi compounds in forest litters, an increase take place in the content of Si, Al, and Fe, and decrease occurs in Ca, Mg, P, K and S element

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IMPROVING SURVEY TECHNIQUES FOR SOIL MAPPING[1]

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THE rapidly developing agricultural economy, as set forth in the directives of the twentieth Party Congress, called for an even greater expansion of soil-mapping in our country. One of the important party and government directives concerning agricultural economy called for executing the agricultural program in various ways relating to the particular nature of an area. Thus, to carry out soil mapping surveys especially for large-scale maps, it is essential to highlight, correctly and scientifically, those natural characteristics peculiar to the area mapped. High-order accuracy and a sufficiently detailed description of soil structures are required as well as the most detailed information about the individual soil classification characteristics.

Obviously, in order to compile soil maps of such fine quality in a short time, soil scientists not only must meet problems of classification, but also must seek means to improve the techniques of field research. Our publications contain the statements of many scientists who have expressed repeatedly the need for technical improvements in our field surveying practices (12, 6, 9, 14). Much improvement still remains to be made, however, in current field methods of soil exploration. Pursuant to this, the present paper discusses certain problems for the technical improvement and increased effectiveness of the work of the soil scientist who uses data obtained from aerial photographs and M. A. Artanov's automatic level.

Utilization of Aerial Photography

Two fundamental tasks confront the soil scientist in the mapping of soils. The first is the identification of the prevailing soil cover and evaluation of the classification system. The second, closely associated with the first, is the actual compilation of the soil maps. This section, however, will deal with only a few matters connected with the second task.

A soil map must represent a reduced, ge eralized, mathematically constructed represent tion of the earth's surface on a plane and sho not only elements of the geographic base b also the distribution of soil cover and its rel tionship to the various elements of the lan scape. The principal defects in soil surveyi and the compilation of soil maps occur most fr quently because of inaccuracy in the determin tion and plotting of soil boundaries and profile in transferring them to the geographic base, ar in the slow pace of the soil scientist-cartogr pher.

It is known that under certain conditions, t mapping of soils of an area has been accelerate by reducing the number of fundamental so profiles, core samples, and other factual dat which use broad interpolation methods. How ever, this procedure produced soil maps of ver poor quality (14).

Acceleration in soil mapping is possible onl by improving the mechanization of core sam pling and borings for soil profiles. Howeve little has been done about such improvemen until the present time. The techniques of ob taining cross-sections are still outmoded. Ther fore, the mechanization of such work on soi means that it is still possible to increase th productivity of the soil scientist-cartographer.

Finally, the accuracy and speed of compilin of a soil map depend on the type and qualit of the base map used. It is quite evident that th higher the quality of the base map, the mo detailed its topographic features and relief, th more accurate the results will be, and the short the survey period. The soil surveyer who us an accurate, fully-detailed geographical ba can make his way to a location with relati ease and speed, establish his position and a curately determine the sites for borings and s profiles. Correctly represented relief on the ge graphical base map permits more accurate plac ment of soil profiles according to the nature the different soil components. Since, over a area, soils vary to a considerable extent wi the relief and also with the peculiarities of t micro-relief, it is clear that a geographical correct base map insures more confident determination and placement of soil boundaries.

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[1] Research was done in the Large-Scale Mapping Laboratory, Soil Institute, Academy of Sciences, USSR under the direction of Professor Yu. A. Liverovskiy.

At present the following kinds of maps can be recommended for use as a base in compiling large-scale soil maps:

1. Land-use plans, on which relief is expressed by contours.
2. Topographical maps.
3. Land-use plans which show relief or topographic maps combined with aerial photographs.
4. Rectified aerial photographs or plans (generally with stereoscopic representation of relief).
5. Land-use maps without relief maps.

Land-use maps having relief representation and topographic maps are good bases for the compilation of large-scale soil maps, (Fig. 1, A). The latter are better geographical bases since they show many more features than do land-use plans. Maps of both types make it possible for the soil scientist to compile a representation of the area and to select the most favorable routes and areas for measuring soil profiles. Relief representation makes it possible for the soil scientist on field assignment to determine more easily and accurately the boundaries of more or less naturally divided soils.

However, one cannot visualize in advance the soil characteristics of an area to be mapped merely from topographical or land-use maps. It is also impossible (irrespective of the varying skills of the specialists) to determine the boundaries and contours of certain types of soils. Moreover, the representation of relief on topographic or land-use maps is expressed by contour intervals which are too large for soil mapping purposes. According to present instructions for topographical surveys, contour intervals are two meters for the 1:10,000 scale maps, five meters for the 1:25,000 scale, ten meters for the 1:50,000 scale and 20 meters for the 100,000 scale maps (8). However, in flat areas, the relief profile must be represented by intervals smaller than two meters if precise soil profiles are to be obtained. Many soil properties are closely associated with micro-relief, a feature which is not indicated on a geographical base at all. Any combination of these features can cause trouble and slow down the work of a soil scientist in compiling large-scale soil maps and result in reduced accuracy and quality. However, by using aerial photographs these deficiencies can be obviated, since such data very quickly provide a considerable amount of accurate information. Compared to topographic or land-use maps, aerial photographs give a much more detailed representation of the earth's surface. Similarly, they can immediately or indirectly offer a representation of soil profiles and their inter-relationships with other landforms, (Fig. 1, B).

That is why soil scientists who make use of aerial photographs are able to determine the following prior to departure for the field: 1) A definite idea can be established of the nature of the existing soil groups; 2) In many instances, preliminary delineation of soil boundaries, and profiles can be verified and finalized on the map from later field observations; 3) The most effective routes for the field survey can be determined and the best positions chosen for core sampling and profiles. On the basis of a stereoscopic study of aerial photography, a soil scientist can get an idea of the structure of the area to be investigated. However, the absence of contoured relief on aerial photography makes certain deficiencies obvious. Consequently, the best bases for compiling soil maps at the present time are those made by combining either topographic maps or land-use plans having relief representation, with aerial photography. As a rule, the use of aerial photography for large-scale soil mapping increases the accuracy, speed and work volume of the soil scientist. A portion of a forest-steppe area was chosen as an example. A map of this area was compiled first without using aerial photography and then with it (Figures 1, C and 1, D).

Careful comparison of these two figures reveals that the use of aerial photography permits a considerable degree of accuracy in the production of soil mapping regardless of the subjective character of the investigator. In particular, the aerial photograph (Fig. 1, B), of the type area clearly shows the locations and boundaries of the light-gray, forest, strongly podzolized soil (low humus content) and the eroded sandy soils. The contacts of the gray and dark gray forest soil, and so forth, are equally discernible without undue effort. Often, having such clear identification at hand, the soil scientist can avoid the tedious task of field delineation of soil boundaries. This helps to speed up soil mapping work. Finally, aerial photography makes more complete soil mapping possible since it clearly distinguishes the differences between soils which result from micro-relief and soil erosion. Thus, in Figure 1, C, north of the river on the lower

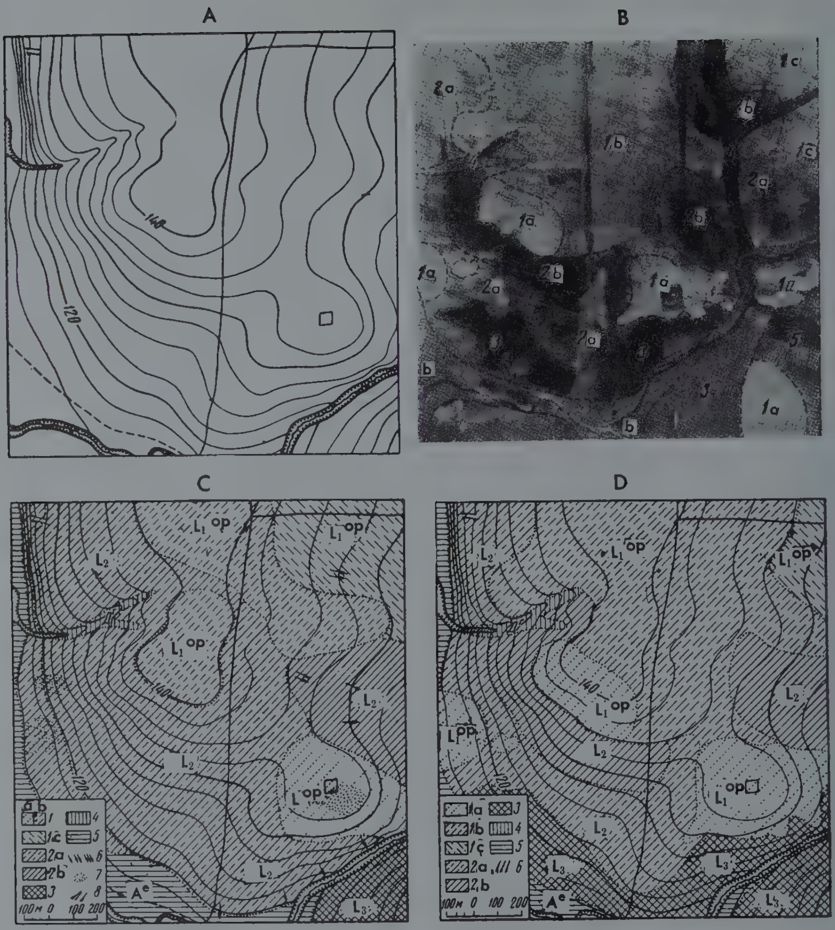

FIG. 1.—Sample section of a forest-steppe area of Ryzanskaya region.

A—Sample section of the 1:10,000 topograhpic map in the forest-steppe area.

B—An aerial survey of the same area on a 1:17,000 scale. 1—light-gray forest soils, strongly podzolized (low in humus): a)—sandy, eroded; b)—sandy or sandy loam; c)—medium clay loam; d)—gray forest soils; a)—sandy and sandy loam; b)—medium clay loam, with sign of alluvium; 3—dark-gray forest soils similar to slightly podzolic medium clay loam; 4—gleyed sod soil and gley soils; 5—gleyed sod soil, dark-gray leached soils; 6—alluvial (flood plain) sod soils.

C—Sample section of a soil map on a 1:10,000 scale in the forest-steppe zone compiled without the use of aerial survey data (by A. A. Vidinoy and I. I. Mamay, supervised and edited by N. P. Lebedev). 1—light-gray forest soils, strongly podzolized, but low in humus: a)—sandy to L_1^{op} sandy, b—sandy and sandy loam to L_1^{op} sandy loam, c—medium clay loam to L_1^{op} clay loam; 2—gray forest soils: a)—sandy or sandy loam to L_2 clay loam, b)—medium clay loam to L_2 clay loam; 3—dark-gray forest soils, slightly podzolic medium clay loam to L_3 clay loam; 4—gleyed sod soil and gley soils to D^g; 5—alluvial (flood plain) sod soils to A^D; 6—eroded soils: a)—slighly; b)—moderately; c)—strongly; 7—small strips of soils subject to wind erosion: a—eroded gullies.

D—sample section of a soil map on a 1:10,000 scale in the same forest-steppe area; compiled with aerophotographic data. 1—light-gray forest soils, strongly podzolized but low in humus: a)—sandy, eroded to L_1^{op} sandy; b)—sandy and sandy loam to L_1^{op} sandy loam; c)—medium clay loam to L_1^{op} clay loam; 2—gray forest soils: a)—sandy or sandy loam to L_2 sandy loam, b)—medium clay loam with signs of alluvium to L_2 clay loam; 3—dark-gray forest soils, slightly podzolic, medium clay loam to L_3 clay loam; 4—gleyed sod soil or gley soils to D^g; 5—alluvial (flood plain) sod soils to A^D; 6—eroded gullies.

lope, the boundary of the dark gray forest soil, hich should appear on both sides of the river, s indicated south of the river only. This bound-ry is clearly shown in the aerial photograph Fig. 1, B) and if aerial photography had been sed, it could not have been missed.

At present, aerial photographic materials are vailable for a considerable portion of our ountry. Therefore, if topographic or land-use naps having contoured relief are not available or areas to be investigated, the best method is o use rectified photo mosaics or photo plans generally with stereoscopic relief representa-ion). These materials, in conjunction with ae-ial photography, can be used not only as geo-raphic bases but also for precise, individual oil delineations. It is obvious that more precise nd better quality soil maps are obtained by sing photo plans which show relief than by using ectified photography. However, it should be ioted that this type of aerial photography is nore expensive than others. Finally, in the in-erest of efficiency, I would like to recommend hat for accurate soil mapping, it is highly ex-pedient to derive the reproduction scale from he rectified photo mosaic or plan.

Land-use plans without relief representation re not useful as high-quality bases because soil naps compiled on such bases do not satisfy ontemporary requirements of accuracy and uality required for our agricultural economy. Moreover, expenses incurred by soil scientists' tudies using such bases are unproductively reat.

The process of compiling soil maps is usually ubdivided into three stages: preliminary office vork, field work, and final office stage.

These stages may be subdivided still further lepending on the specifications for soil classifica-ions relative to the aerial photographic mate-ials.

Preliminary Office Work

This first office period includes the preliminary lassification of soils from aerial photography.

First Stage. The examination of soils should be initiated with an overall review of the terri-ory from rectified mosaics prepared from aerial photography, a reproduction of this mosaic, or a photo plan. In the event that topographic naps are available for the same area, it is nec-essary that they be constantly compared to the aerial photo material. During this process small areas are delineated as having more or less uniform natural characteristics. The isolation of similar sections will permit still further detailed identification from the aerial photographic materials.

Together with the detailed analysis of the aerial photography, the descriptive literature and cartographic data for the regional study and its adjacent territories should be used as well as their physical-geographical conditions. If topographic or land-use maps having relief representation were used in conjunction with aerial photographs in the compilation of the geographic base, then only a preliminary identification of soils is made from aerial photographs during the first and second stages. If, however, rectified photo mosaics or plans are used as the geographic base for soil mapping then, in addition to soil identification, topographic features may be delineated from the aerial photos as well. Delineations of topographic elements can be developed very well and to a considerable degree during the preliminary office operations. Usually they are made in the next stage. Elements included in the geographic base for soil map compilations are the following: the drainage network, relief, forests and swamps, populated places, communications and certain other topographic features characteristic for any given area. Simultaneously with the delineation of topography, a preliminary soil identification is made.

Second Stage. This includes a more detailed investigation of the aerial photographic materials relative to the nature of the individual soil cover. Best results are obtained by using stereopairs in strips as a base, and the reflecting-lens stereoscope, LZ-NIIP.

Depending on the nature of soil delineations, hypothetical soil type boundaries are sketched. Then, all delineation data are divided into these three groups in order of authenticity: reliable, doubtful and undefinable under office conditions. The results of these preliminary delineations are then transferred either to the aerial photographic material or to an overlay. Field routes are also marked on this preliminary, stereoscopic, soil-delineated, aerial photographic base, as well as those areas in which soil profiles are to be made which reasonably enough might be defined more accurately under field conditions. As a result of such an investigation, which comprises observations of adjacent territory, soil cover, drainage network, orographic features of the area, soil erosion processes, and so forth, may be shown. For this series of features, the photographic image on the aerial photographic materials may be indistinct without field research.

Field Work

In the field the correlation and description of soil profiles are carried out simultaneously with the field identification of soils.

Third Stage. While making reconnaissance surveys, usually in the initial stages of the field work, general familiarity with soil characteristics is acquired. At this stage, also, certain bases for the identification of the most characteristic criteria for soil identification from aerial photographs are determined. Thus, as a result of a circuit around the Sapozhkovskiy area of Ryazanskiy region, it was determined that the light-gray, forest, strongly-podzolic, clay loam soils, appeared on the aerial photos as a mottled pattern of light shades, but the light-gray, forest, weathered, sandy spots showed up as patches of bright gray shades, and so forth.

Fourth Stage. In the early stage of soil mapping, after attaining an overall familiarity with the soils of the area under study, it is especially important to establish firm criteria for the identification of individual species of soil types. A detailed interpretation of all soil characteristics as they appear on the aerial photography is made. Both the basic and the subsidiary criteria of the interrelationships of soil patterns to relief and vegetation are carefully worked out. The soil scientist takes enough soil borings to permit him to proceed to the next phase of the work.

Fifth Stage. During this period the soil scientist also maps and delineates the soils in detail. By combining data obtained from test borings with those determined for identification of soil types, it is possible to delineate the soil cover existing in areas between surveyed routes by applying the principle of geographical analogy. Next, soil profiles previously selected in the laboratory are evaluated and the final selection and revision is made in the field. The number of basic soil profiles necessary to compile soil maps from aerial photography varies but little from that of the conventional method. However, their number, as well as those of soil samples can be sharply decreased when good definition of soil boundaries and soil identification can b made from aerial photos. As a result, the so scientist using aerial photography in the fiel gains additional time for deeper soil analysis.

All field work for a large-scale soil survey executed most expeditiously in conjunction wit aerial photography. Soil boundaries and othe features are sketched on the aerial mosaics wit a pencil, obtaining contours traced from th photographs. At the same time, one should attempt to confine this delineation to the centra portion of the survey where there is less distortion.

After correlating information obtained from stereoscopic examination of the aerial photos all data are transferred to the geographic base whether it is a topographic map, a land-use map with relief representation, a photo mosaic or a photo plan. This is the final step in the field work for a soil study.

Final Office Work

The results of soil identifications and other data for large-scale soil surveys undergo final checking in this laboratory stage. After analytical studies have been made of soil samples, and checked against the aerial photography, soil contours are given a final revision and are drafted. Lastly, results of the field survey obtained by aerial methods are drafted in soil map form; the legend is finalized and explanatory notes prepared.

Use of M. A. Artanov's Automatic Level

For large-scale soil investigations it is very important to investigate variation of soils relative to diversity in relief and nature of the micro-relief. However, as demonstrated previously, topographic maps and land-use plans with relief representation are clearly deficient in representation of micro-relief in the area to be mapped. As a result, the soil scientist cannot make a detailed study of the various soil layers in relation to the micro-relief. Daily records of conditions of soil deposition and individual soil boundaries, logically enough, because of their somewhat subjective character, do not reflect true conditions on soil maps.

Nevertheless, the investigation of conditions of soil deposition relative to relief plays an important part in the determination of the nature and control of soil-forming processes (4, 5). Thus, the distribution and degree of soil moisure depend on relief and micro-relief; the depth f snow cover, on the degree of slope (on conave slopes, snow accumulates but on convex lopes, it blows away); the exposure and angle f slope inclination have a considerable effect n surface irradiation, and so forth. Therefore, or a complete investigation of soil deposition onditions relative to relief, the best possible eveling profiles necessary for that particular oute should be used (14).

The use by a soil scientist of an optical level o make a surface profile requires special traing, additional expenditure of the worker's enrgy and appears to be too time consuming. As result, the soil scientist's field studies must be omewhat reduced. Moreover, an area profile obained with an optical level will not be continuus, and will be characterized only by individual oints on the earth's surface.

By far the best results for soil purposes are btained with the automatic level. M. A. Aranov's automatic leveling method offers a self-ecording geodetic instrument, mounted on a wo-wheeled hand cart on the order of a bicycle. t automatically records a continuous route prole as it rolls across the area. The continuity f the graphical record is very necessary for soil urposes since, in this case, it will be accurate nough to show all forms and declinations of lopes and will completely eliminate any blank reas between determined points, (Fig. 2). The ccuracy performance of the automatic level aries from 0.15 to 0.30 meters in elevation per ilometer when leveling is speeded up to aproximately three to four kilometers per hour. leveling profile obtained by using this instruent depends very little on the weather and the ature of the terrain and may be used during eriods of poor visibility, in fog or in the forest. aboratory procedures to obtain data do not equire as much basic computational work as is ecessary with the optical level. Instrument opration is very simple. One field man can handle he field work under the supervision of a soil cientist. Without dwelling at length on the contruction of Artanov's automatic level and its haracteristics, we will merely note the instrucions as given in (1), including only the most mportant sections and operating procedures ealing with field investigations.

The automatic level consists of a self-recording evice fastened to bicycle wheels. An instrument, ounted on the rear wheel, composed of a shaft and gears connected to a recording device automatically records the profile on a strip of millimeter graph paper. A small pendulum is attached to the lower portion of the recording device, reacting to each measurement of the surface. The instrument has a recorder which is numerically adjusted according to the relief of the area and the nature of the work. An indicator, attached to the top of the recording device is used to mark special points of interest along the profile, such as soil boundaries, profiles, and so forth. Finally, the device has a small spool on which is wound a roll of paper marked off in millimeters, 15 mm. long and 120 mm. wide (—0.1 to 0.2 mm.).

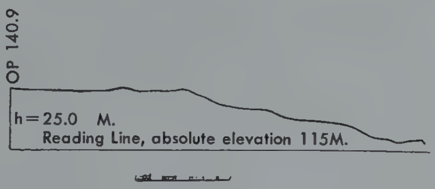

FIG. 2.—Sample record of a profile of an area measured by M. A. Artanov's automatic level. (Vert. Scale—1:500, Hor. Scale—1:5,000)

Work procedures adopted for use with the automatic level follow. After selection of the fundamental routes, from a map and in the field, elevations closest to them are selected and marked. One route is chosen to be measured by the automatic level. Before putting the instrument into operation the vertical scale (1:5,000 or 1:2,000) is selected for the observations, including the gear ratio in the rear wheel of the instrument containing the recording device; the pendulum is loosened from its casing and the millimeter recording pencil placed in the most advantageous position for the predetermined route. (If the probable slope is inclined, the pencil is moved along the shaft toward the left side of the instrument). The initial position is recorded, and the counter reading and the absolute elevation of the point are observed from the indicator on the millimeter strip. Then the instrument is gently started and rolled along in the designated direction. At soil boundary intersections or soil profiles, the instrument is gently stopped and the indicator makes the appropriate mark at that point on the profile. Whenever the soil technician is taking test borings along the profile, the automatic level must be positioned on the ground along the profile line in such a way that the instrument cannot become entrenched. The instrument is moved to one side or the other when turns are made. In this case, if a sharp turn is required, it is necessary to elevate the front wheel of the instrument and turn it in a direction that prevents the rear wheel from moving. The turning point should be recorded by the indicator on the profile. The instrument will record slopes up to 45°. If the slopes in the area are steeper than 45°, the automatic level should be propelled, not along the direction of the steepest slope but at some angle to it. Occasionally the pencil reaches the outer edge of the millimeter tape. Whenever this occurs it is necessary to note it on the profile line, both before and after it slips off the edge.

Upon completion of work on the profile the elevation of the second end of the route must be determined and recorded on the very same day. In the event that this identification is missing, it may be impossible either to move the automatic level along the measured direction or to suspend leveling along that direction. In the latter instance, observation of the absolute elevation of that point on the profile will necessarily be less accurate than the first.

Moreover, it should be noted that whenever the absolute elevations of individual profile points are of little concern to the investigator, it is possible to speed up the work since the requirement of tying the profiles to known elevations can be neglected.

The laboratory processing of the graphical representation of the area profiles determines the criteria for all required points as finalized by laying out a line of the readings. At the beginning and end of this line the various elevations along the route are plotted on the vertical scale. By connecting these points with a fine line, the reading line is obtained. The distance of any point on the profile from the reading line can be derived from any given point on the vertical scale.

In conclusion, it should be noted that the use of the automatic level is not limited to investigation of soil deposition relative to relief. Profile leveling with this instrument can be used successfully to investigate problems associated with soil erosion and, to some extent, for qualitative evaluation of erosion and deposition. It is very important to demonstrate the use of the automatic level in development work because the establishment of a levelled route across slope makes it possible to obtain a continuou profile along an assumed direction of drainag Finally, the automatic level can help determin available elevation bases in series to be used t compile large-scale soil maps with relief representation as well as to provide elevations fo projected aerial photography, and so forth.

Conclusions

1. Improved research for compiling large-scal soil maps depends, to a considerable extent, o the nature of the base map. In this connectio we must state that, at the present time, the bes bases for soil mapping are derived from usin aerial photography in conjunction with eithe topographic maps or land-use plans with relie representation, or photo maps with relief representation.

2. The use of aerial photography of sufficient quality to compile large-scale soil maps permits the soil scientist to determine in the laboratory the nature of the soils in the area to be mapped to project a series of boundaries and contours of individual soil cover which can be observed later *in situ*, by field work. During that field stage, aerial photography, owing to the comparatively excellent delineation of boundaries of soil contours, as well as the possibility for soil identifications in the areas between routes, makes it possible to carry out more accurate and rapid soil mapping.

3. For soil research involving the investigation of soil deposition relative to relief, for soil erosion, for improving correction procedures, and so forth, considerable attention should be given to compilation in accordance with the nature of the selected area profile. The best procedure for this operation is M. A. Artanov's method.

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A METHOD FOR MEASURING THE WIND EROSION DEPTH OF SOILS

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In order to combat the harmful results of wind erosion of soils, it is necessary to measure its effects. This is complicated by the difficulty of measuring wind erosion depth, especially in areas under continuous cultivation. Existing measuring methods cannot be applied under field-surveying conditions and are even more complicated in the case of field-station investigations on arable land (1, 3).

The process of deflation, depending on its intensiveness and the soil properties, usually removes the finer (lighter) soil particles from the soil surface, while the coarse (heavy) particles remain or are slowly shifted on the surface. As a result of this, in regions of continuous strong winds an appreciable amount of wind eluvium accumulates on the soil surface in the form of fine gravel, stones, rubble, and so forth.

In order to appraise the volume of the soil layer removed, Sobolev (3) proposed to compare the weight of stones on the soil surface with that of stones in the soil mass. This proposal was considered by us while working on a method of measuring the depth of wind erosion of soils that had developed on dense sedimentary rocks and pliocene clays.

The method proposed by us is as follows. In the field where the wind erosion depth has to be measured, control plots measuring 50 × 50 cm. are laid down. The number of plots laid down and their distribution over the eroded area depends on the purpose of the investigation. Each control plot characterizes the depth of soil erosion in the given spot.

After the plots have been laid down, all vegetation is cut down to the root with a gardener's knife, and every fine stone and piece of pebble is collected from the exposed surface. For convenience, the surface of the control plot is divided into nine parts. The upper soil layer ($\sim$2 mm.), together with the stone and pebble, is carefully swept with a small brush on to a trowel from each ninth part of the plot. Here it must be emphasized that the accuracy of the measurement of the depth of wind erosion will depend on how carefully each stone and piec of pebble is collected within the control plot. Th collected stones and pebbles are separated fro the fine-earth of the soil by sifting through sieve with a 2 or 3 mm. mesh.

When selecting the sieve it is necessary t know the minimum size of the wind eluvium o the soil studied. Normally the wind does no carry away particles of a diameter greater tha 3 mm. It follows that the mesh of the sieve mus be 2 to 3 mm.

The upper soil layer is normally dry, an sifting it offers no difficulty. The stones and peb bles sifted off are weighed with accuracy to 0. gm. and the fine-earth which passes through th sieve is transferred to a calibrated glass cylinde and its volume measured. When the volume o the fine-earth and the size of the control plo are known, it is easy to calculate the thicknes of the soil layer removed for counting the stones This is necessary for purposes of checking an calculation of correction if other particles no representing wind eluvium are collected with the soil. Collecting the particles of smallest diameter without disturbing the top pulverized soil layer is fairly difficult, so that the thickness o the soil layer collected should not exceed 2 mm in the present case.

After this, a determined amount of soil with undisturbed structure is collected from the control plot with a soil sampler. For this purpose we used sampler from the Litvinov field laboratory. The diameter and height of the wall of the sampler were 4 cm. The soil is collected by layers, without a break, from three holes within the control plot to the depth of the cultivated layer that is to 20 cm. Normally, 12 to 15 samples on each plot are quite sufficient. The data obtained will characterize the depth of wind erosion of soil after the last cultivation. Because soil is usually moist and not amenable to sieving it is necessary to transfer each sample quantitatively to an aluminium container, dry it in drying cupboard under air-dry conditions, trans r it to a mortar, grind it with a rubber pestle ıd then sieve it.

The stone content per 1 cm. of soil layer will ıual P/4, where P is the weight of soil stones er sampler-volume and 4 is the height of the mpler in cm. The weight of stones collected on ie control plot computed to the area of the mpler section equals:

$$P_1 \cdot \frac{12.56}{2500} \text{ gm.}$$

The ratio of the latter weight to the weight of ie stones contained in 1 cm. of soil gives the ılue:

$$P_1 \frac{12.56}{2500} : \frac{P}{4} = 0.021 \frac{P_1}{P} \text{ cm.}$$

here 0.021 is the constant value for a given ımpler.

TABLE 1

ata and calculations of measurement of depth of wind erosion of soil (H) in cm.

lot um- er	Soil characteristics	Weight of particles >2 m. (in gm.)		Ratio $\left(\frac{P_1}{P}\right)$	H = 0.021 × $\frac{P_1}{P}$
		On control plot (P_1)	Sampler-Volume (P)		
1	Chernozem, southern fine clay loam, overlying tertiary clays. Northern slope 3–4°	24.0	1.15	20.9	0.4
2	Same, upper part of 3–4° slope	85.1	1.56	54.6	1.1
3	Same, southern slope 3–4° slope	51.7	1.35	38.3	0.8
6	Same, upper part of northern slope 3–4°	35.0	0.90	38.9	0.8
11	Carbonate chernozem. Southern slope 3°	28.6	0.47	60.9	1.3
12	Same, but thinner at foot of slope	46.7	0.55	84.9	1.8
13	Same, but on the plateau	159.7	1.95	81.9	1.7
16	Chernozem, southern fine clay loam, overlying tertiary clays. On the plateau	72.1	1.86	38.8	0.8

TABLE 2

Results of calculation of wind erosion depth with and without statistical analysis[a]

Control plot number	$H = 0.021 \frac{P_1}{P}$ cm.	$H_1 = 0.021 \frac{P_1}{P_2}$ Cm.
1	0.4	0.4
2	1.1	1.1
4	0.8	0.7
6	0.8	0.9
11	1.3	1.2
12	1.8	1.7
13	1.7	1.6
16	0.8	0.8

[a] P is the arithmetical mean of 12 samples; P_2 is the arithmetical mean after discarding extreme variants outside M ± m.

TABLE 3

Volume and thickness of the layer of soil collected from control plot

Control plot number	Volume of soil, cm.^{3}	Thickness of soil layer, cm.	Value of correction, cm.
1	390	0.15	0.0
2	380	0.15	0.0
4	600	0.24	0.0
6	700	0.28	0.1
11	600	0.24	0.0
12	610	0.24	0.0
16	390	0.15	0.0

Thus, the depth of wind erosion of soil is calculated according to the formula:

$$H = 0.021 \frac{P_1}{P} \text{ cm.}$$

where H is the depth of wind erosion of soil in cm., P_1 is the weight of stones and pieces of pebble from the control plot of 0.25 m.^{2}, and P is the weight of stones and pieces of pebble in the soil per sampler.

Using this method under field-survey conditions we examined characteristic wind-eroded regions in the Crimean steppe. One of the chief aims of these examinations consisted in determining the depth of wind erosion of soil resulting from a spring dust storm. This work was carried out in the Sak and Simferopol regions of the Crimea on southern and carbonate chernozems. Some results of the investigation are given in Table 1.

These data show that the content of particles of diameter >0.2 cm. fluctuates, in a determined amount of soil from one and the same field, between 0.90 and 1.56 gm., corresponding to 1.4 to 2.4% of the soil weight.

Extracting the arithmetical mean with 12 to 15 replication gives fully satisfactory results in comparison with the method of discarding the extreme variants outside M ± m (2), where m was found by the formula:

$$m = \sqrt{\frac{\Sigma a^2}{n(n-1)}}.$$

This is clear from the data in Table 2.

As was pointed out previously, the volume of soil collected from the surface of the control plot and passed through the 2 mm. mesh sieve was measured in a calibrated cylinder. After that, the thickness of the soil layer collected from the plot was calculated. The results obtained are given in Table 3.

Because the thickness of the soil collected from the control plot should not exceed the gauge of the sieve's mesh, the results of calculating the depth of wind-erosion of soil on plot No. 6, according to Table 3, should be reduced by 0.1 cm.

In conclusion, it should be observed that the described method can be applied on soils containing particles larger than 2 mm. This method can be tested also under field-station conditio with soils developed on loess, loess-like cla loams, and forest sands by laying down artifici control plots. For this purpose a layer of soil removed to a depth of 30 to 40 cm. on a plo measuring 1.5 m.^{2} on experimental fields. Th soil removed is uniformly mixed with sorte stones or pieces of pebbles in the proportion 3% to 4% of the soil weight. Then the soil carefully replaced in the hollow from which was taken. Such control plots will not be hindrance to agricultural cultivation, and the allow systematic observations on the process o wind erosion.

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OME TYPES OF SANDHILLS ON THE DON RIVER

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A study of sandhills on the Don was made on three sandy areas of mountains in the eppe zone,—Chirsk, Pridonetzk and Archedin- o–Donsk.

The Chirsk sandhills were studied by using st plots established on sandy areas at the NIALMI Oblivsky substation for melioration agriculture and forestry, Rostov district, in a ction of extensive dark chestnut soils. Studies Donets sandhills were carried on at the Ka- ensky forest management farm, Rostov dis- ict. In this region, the soils are predominantly uthern chernozem. Archedinsko-Donsk sand- lls were studied at the transition point from uthern chernozems to dark chestnut soils, on e territory of the Archedinsk forest farm, talingrad district.

Our investigations (1, 3, 5, 6, 7 and others) ave shown that one of the decisive factors in roducing a vigorous forest growth is the tex- ural soil profile, that is, the particle-size compo- tion of the different strata, and their depth acement. If the topsoil layer of sand and sandy am contains fewer clay and silt particles than e horizon directly below, the existing condi- ons of moisture supply and retention are favor- le. This is very important in steppe regions. ith this type of textural profile, soil fertility creases. In other words, the best conditions for rest growth are present when the soil profile as: a) a sandy top layer, and a layer of sandy am or clay loam below; b) a topsoil layer of ndy loam and a deeper layer of clay loam; c) ndy layers alternating with sandy loam or clay am.

Experience with planting forest strips in sandy rritories of the steppe zone in the European SSR, has shown that it is impossible to build fective windbreaks of forest strips without nsidering the textural soil profile. Figure 1 ves some idea of the influence of textural pro- e on growth of a 41-year-old pine plantation Pridonetz sands, Rostov district). The figure ows that pine grows well on Aeolian sands er buried sandy loams at a depth of 105 cm. Stands of pine produced on soils of this kind are of III site quality. On the summits of medium-sized hills and in depressions between the hills where the upper stratum is alluvial sand about 140 to 145 cm. thick, underlain by buried sand of uninterrupted textural profile, the strip pine plantings are of IV or V site quality.

From what has been stated, it follows that the textural soil profiles should serve as a basis for sand classification. Thus, the sandhills of the Don steppe zone may be divided into three basic types or groups:

First type: Aeolian sands over buried soils.

Second type: Aeolian sands over buried sands of uninterrupted texture.

Third type: Sands of uninterrupted texture.

Each of these sand types has its own special features which determine their utilization.

First type—*Aeolian sands over buried soils.* These are generally better adapted to afforestation than the second and third types. Here, the sandy loam or clay-loam subsoils act as moisture-retaining layers, holding the water precipitated from the atmosphere on the upper strata of alluvial sand and thus creating favorable moisture conditions. In texture and in humus content, Aeolian sands on buried sandy loam or clay loam are characterized in Table 1.

The Aeolian sands of Chirsk are basically medium grain size. Their content of medium sand varies from 36% to 71%; of fine sand, from 23% to 58%. The Donetz Aeolian sands are classified as fine grained in texture. The fine sand makes up 60% to 90%, the medium grained 10% to 38%. Aeolian sands contain, on the average, 0.2% to 0.3% of humus.

The average thickness of Aeolian sand is about 100 cm. (and up to 235 cm.). Buried sandy loam or clay loam is deeper. Textural soil profile of this type, with strata having a high content of clay and silt particles, accounts for better conditions of moisture supply and retention. We can see this in data given below (O. N. Korolëva, 4).

Soil feature	Depth, cm.	Moisture, % of dry soil
Sand	160	3.09
Sandy loam	185	22.21
Sand	230	2.54

In sands of this kind, the best growth of pine plantations (site quality II to III) is obtained when the buried soils are located at a depth of 0.5 to 1.5 meters, and when the underground water is at a level of about 7 meters.

Where the buried soils under Aeolian sands are also sandy, conditions for forest plantings are less favorable. This is because such soils do not differ much in texture from the upper alluvial sand layers. When atmospheric precipitation falls on alluvial sand, it quickly seeps through to the lower strata, leaving almost no moisture in the subsoil. Pine can be grown successfully in such sandy areas provided the underground water table is not too deep (at an average depth of 2 to 3 meters).

The summits of high and medium hills make poor locations for growing forests (site quality IV to V). Here, the buried sandy loam or clay loam lie below 1.5 to 2.5 meters. In summertime, the moisture content of the Aeolian sand layer of these hills drops to 1% to 1.5% or the amount designated as "unavailable" water.

According to V. R. Williams (2), different kinds of soil contain the following amounts of unavailable water: sandy soil—1.5%; sandy loam—2.2%; clay loam—4.7%; chernozem–14.7%.

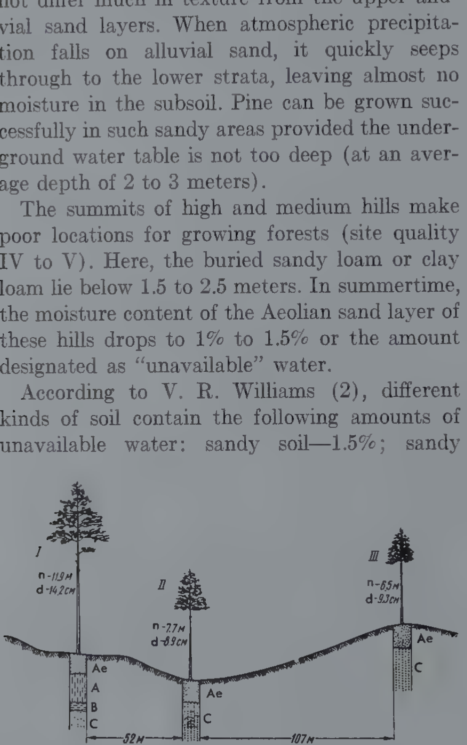

FIG. 1.—Effect of soil textural profile on the growth of 41-year-old pine plantation on Donetz sands. Rostov district. I. Ae (0 to 105 cm.)—Aeolian sand; A (105 to 205 cm.)—buried soil of sandy loam; B (205 to 235 cm.)—clay loam; C (235 cm. and deeper)—sand of uninterrupted texture. II. Ae (0 to 140 cm.)—Aeolian sand; C (140 cm. and deeper)—sand of uninterrupted texture with pseudofibers. III. Ae (0 to 143 cm.)—Aeolian sand; C (143 cm. and deeper)—sand of uninterrupted texture (Drawing by the author).

The first type of sandhill is the most common Average height of the hills is 3 to 4 meters (an up to 10 m.).

Aeolian sands over buried sandy loams an clay loams are generally usable for growing for est strips, provided the other conditions are suc as to assure success. Smooth, low, sandy hills o this kind, with buried sandy loam or clay loam below, are well suited for truck-gardening o melon.

Second Type—*Aeolian sands over buried sands of uninterrupted textural profile.* These have a particle size analysis given in Table 2.

Aeolian sands with a buried soil of continuou sands are fine grained. The content of fine sand is 46% to 94%, of medium fine sand, 53%. The humus content averages about 0.2%. The average thickness of the Aeolian layer is 1 to 1.5 meters, on the tops of high hills it is 3 meters or more. The usual height of the hills is 3 to 7 meters, maximum 11 to 12 meters. Sandy hills of various shapes alternate with windblown basins, also of diverse configurations. The thickness of sand formations on the territory of Archedinskiy Don is as high as 48 to 59 meters; on the sandy terrace of Severny (Northern) Donetz, it is 15 to 20 meters. Here and there among the sandy formations are clayey strata, 20 to 30 cm. thick, and more.

Sandhills of the second type occur throughout the territory of the Archedinsky Don sandy area and on the sand terrace of Severnyi Donetz, in the steppe zone. In the depressions and on the slopes of hills where the ground-water level is inaccessible to plant roots, the site quality of pine plantations is III to IV (Fig. 2). On tops of hills, site quality is IV to V. The only moisture available to pines growing in these sandy places is atmospheric precipitation. Roots penetrate down to a depth of 250 cm.; the greater bulk of the root system is distributed throughout the upper stratum which is 1 to 1.5 meter thick. In places where the ground-water table is at the depth of 4 meters, the site quality of pine plantings improves up to II or I. Here, the tree roots reach down to the level of ground waters Sandhills of the second type should be classified as suitable for purposes of afforestation.

Third Type—*Sands of uninterrupted textural profile.* Their particle size composition is given in Table 3.

TABLE 1

article size analysis of Aeolian sands with buried sandy loam and clay loam in percent of dry soil weight

Test plot No.	Location of samples	Relief	Horizon	Depth, cm.	Hygroscopic moisture, %	Diameter particles, mm.					Humus content, % of absolutely dry soil (after Tyurin)
						> 1.00	1.00 to 0.25	0.25 to 0.05	0.05 to 0.01	<0.01	
13	Karaichev forest home. Oblivsky substation Rostov district (Chirsk sandy area)	Slope of medium hill[a]	Ae[b]	5–10	0.10	4.04	63.24	23.36	0.89	8.47	—
			Ae	40–45	0.07	1.08	59.54	37.03	0.33	2.02	—
			Ae	70–75	0.48	0.83	55.81	33.91	1.39	8.13	—
			A	110–115	1.92	0.52	37.10	28.03	9.85	24.50	—
15	“	Summit of medium hill	Ae	5–10	0.32	1.63	52.96	42.80	0.65	1.92	—
			Ae	60–65	0.21	1.01	67.36	29.84	0.35	1.44	—
			Ae	110–115	0.20	3.27	71.16	24.29	0.33	0.95	—
			Ae	125–130	0.38	0.51	58.04	37.84	0.81	2.80	—
			A	165–170	0.99	0.86	57.47	23.04	0.25	18.38	—
36	“	Summit of low hill	Ae	15–20	0.27	0.46	73.75	23.58	0.23	1.98	0.05
			A	60–65	0.07	0.31	53.57	29.18	1.09	15.85	0.15
			A	100–105	0.06	0.31	58.14	36.79	1.38	3.38	—
			B	140–145	1.94	0.91	53.39	19.36	6.98	19.36	—
			C	285–290	0.28	1.21	53.13	41.21	0.99	3.46	—
51	“	Summit of low hill	Ae	15–20	0.44	0.02	41.03	53.95	2.05	2.95	0.37
			A	85–90	0.91	1.21	48.62	36.04	3.39	10.74	0.76
			A	140–145	0.88	1.54	41.86	41.45	4.54	10.61	—
			B	190–195	3.42	0.30	27.28	32.87	10.28	29.27	—
			C	285–290	0.36	3.67	53.60	38.85	0.56	3.32	—
53	“	Summit of medium hill	Ae	15–20	0.48	—	36.24	58.23	1.00	4.53	0.26
			Ae	150–155	0.47	—	66.46	28.91	0.61	4.02	—
			A	235–240	1.09	0.18	37.46	50.12	2.58	9.66	0.88
			B	290–295	0.24	0.06	28.56	45.09	5.43	20.86	—
20	Oulyashkin forestry, Kamensky forest farm, Rostov district	Slope of medium hill	Ae	20–25	0.16	—	38.21	60.10	0.05	1.64	0.18
			A	135–140	0.50	—	22.46	66.08	2.60	8.86	0.35
			B	220–225	2.22	—	19.41	40.33	4.46	35.84	—
			C	350–355	0.16	—	33.05	64.68	0.48	1.79	—
22	“	Slope of medium hill	Ae	20–25	0.14	—	9.82	89.66	0.19	0.33	0.17
			A	100–105	0.37	—	23.35	64.45	0.90	11.30	0.31
			C	170–175	0.03	—	34.62	59.29	0.52	5.57	—
			C	260–265	0.04	—	28.41	70.35	0.35	0.87	—

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[a] The hills are divided according to height into three groups: low, 3 m.; medium, 3 to 7 m.; high, over m.

[b] Ae—Aeolian sand.

TABLE 2

article-size analysis of Aeolian sands over buried sands of uninterrupted texture, percent of dry soil weight

est lot o.	Location of samples	Relief	Horizon	Depth, cm.	Hygroscopic moisture, %	Diameter of particles, mm.					Humus content, % of absolutely dry soil (after Tyurin)
						> 1.00	1.00–0.25	0.25–0.05	0.05–0.01	< 0.01	
18	Oulyashkin forestry, Kamensky forest farm, Rostov district. (Donetz sands)	Summit of medium hill	Ae	20–25	0.19	—	29.98	69.02	0.24	0.76	0.12
			Ae	121–126	0.14	—	48.40	50.68	0.11	0.81	—
			C	151–156	0.12	—	36.50	62.90	0.09	0.51	—
			C	325–330	0.17	—	36.72	62.64	0.10	0.54	—
21		Depression between medium and small hills	Ae	20–25	0.10	—	43.71	55.36	0.21	0.72	0.30
			Ae	120–125	0.07	—	53.45	46.51	0.02	0.02	—
			C	300–305	0.15	—	25.86	72.46	0.37	1.31	—
14	A three-parted forestry, Archedinsk forest farm, Stalingrad district (Archedinsk-Donsk sandy area)	Depression between high and medium hills	Ae	5–10	0.51	—	9.78	86.09	1.34	2.79	0.50
			Ae	30–35	0.11	—	36.17	63.15	—	0.68	0.12
			Ae	60–65	0.13	—	31.56	67.00	—	1.44	0.01
			C	150–155	0.12	—	20.75	78.72	—	0.53	—
			C	300–305	0.11	—	25.93	73.31	—	0.76	—
17	“	Depression between medium hills	Ae	10–15	0.24	—	12.40	85.62	0.63	1.35	0.27
			Ae	120–125	0.26	—	4.77	94.30	—	0.93	0.13
			C	220–225	0.23	—	17.80	81.05	—	1.15	—
			C	300–325	0.32	—	26.75	71.25	0.55	1.45	—

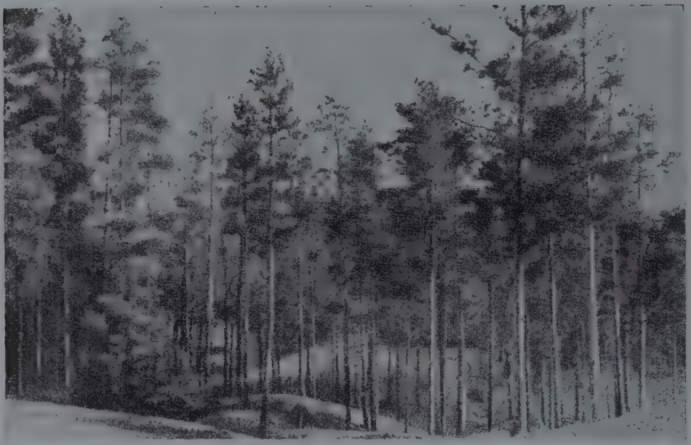

FIG. 2.—45-year-old pine plantation on Aeolian sands over buried sands of uninterrupted texture. (Sandy area at Archedinsky-Don, Stalingrad district; photo by author.)

TABLE 3

Particle-size analysis of sands of uninterrupted texture, percent of dry soil weight

Test plot No.	Location of samples	Relief	Hori-zon	Depths, cm.	Hygroscopic moisture, %	Diameter of particles, mm.					Humus content, % of absolutely dry soil
						>1.00	1.00 to 0.25	0.25 to 0.05	0.05 to 0.01	<0.01	
14	Karaichev forest home Oblivsky substation, Rostov district (Chirsk sandy area)	Depression between medium and small hills	C	5–10	0.37	10.53	61.80	26.82	0.18	0.67	—
			C	15–20	0.13	1.14	60.78	36.47	0.26	1.35	—
			C	45–50	0.17	9.10	57.88	32.01	0.26	0.75	—
			C	150–155	0.26	0.36	54.83	43.49	1.18	1.14	—
33	"	"	C	20–25	0.23	0.40	66.26	31.29	0.02	2.03	0.06
			C	85–90	0.14	1.45	79.26	18.58	0.09	0.62	—
			C	130–135	1.43	4.89	79.88	11.79	0.05	3.39	—
			C	200–205	3.38	0.24	25.08	19.33	14.23	41.12	—
35	"	Depression between low hills	C	10–15	0.25	0.53	63.71	33.68	0.05	2.03	0.13
			C	45–50	0.28	0.96	71.16	25.68	0.06	2.14	—
			C	100–105	1.43	0.71	45.01	35.14	2.31	16.83	—
			C	145–150	0.32	0.05	70.26	27.23	0.05	2.41	—
			C	210–215	0.26	4.75	58.60	34.55	0.06	2.04	—
24	Vyesdin forestry, Archedinsk forest farm, Stalingrad district, (Archedinsk Donsk sandy area)	Depression between medium hills	C	10–15	0.06	—	47.50	51.83	0.15	0.52	0.09
			C	60–65	0.12	—	26.72	71.94	0.67	0.67	0.02
			C	200–205	0.18	—	23.62	72.94	0.96	2.48	—
	"	"	C	15–20	0.10	—	47.67	50.94	0.35	1.04	0.13
			C	63–68	0.13	—	40.63	57.94	0.20	1.23	0.02
			C	131–136	0.12	—	28.15	70.77	0.20	0.88	—
			C	220–225	2.93	—	1.36	10.56	31.69	56.39	—

Within the boundaries of the Chirsk sand area, uninterrupted sands have a medium-grain texture. The number of medium sized particles is 55% to 80%; of fine sand, from 12% to 43%. In sands of the third type occurring on the territory of the Archedinsky Don sand area, fine particles predominate, constituting 51% to 73% of the total. The content of medium sand is 24% to 48%. These sands contain little humus (0.06% to 0.13%). Deposits of sandy loam and clay loa occur at a depth of 100 to 200 cm.

The medium grained sands with uninterrupte texture contain very little moisture: in the summer, their moisture content is about 1% to 1.5% that is, down to the level of "unavailability."

The third type of sand occurs very commonl n combination with the first and second types, sually in the form of windblown craters. Sands f this type are found in even plains and in hilly oil reliefs. In the latter case, the ancient deosits, uninterrupted texture, consist of alterating strata of sand, sandy loam or clay loam, ach averaging 10 to 20 cm. in thickness (or rom 1–2 to 50–60 cm. each).

Sand areas of the third type, with a medium-rain texture and with the ground-water table ocated at a depth of 1 to 2 meters can be utiized for afforestation. If the underground water evel is deeper than 2 meters, these areas are unuited for forestry.

Conclusions

1. The sandhills of the Don are very diverse n their textural soil profile, that is, in particle-ize analysis. This diversity of texture implies a iversity in conditions for plant growth. Without onsidering these conditions, we cannot have a uccessful reclamation program on sandy terriories.

2. A classification of sandhill types should be ased on the textural soil profiles, that is, on the article-size analysis of the soil strata and their ocation in depth. Accordingly, the Don sandills can be divided into three basic groups or types, namely:

First—Aeolian sands over buried soils.

Second—Aeolian sands over buried sands with uninterrupted texture.

Third—Sands of uninterrupted texture.

3. The proposed classification for sandhills of the Don River may be of some help in our further studies on conditions suitable for afforestation, and also in determining the possible use of sandhill territories in an agricultural economy.

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EARTHWORMS AND OTHER INVERTEBRATES INHABITIN FOREST SOILS IN THE VOLOGDA REGION

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SOIL fauna is an important component of the biogeocenosis of forests. But the amount of data describing the soil fauna typical of different kinds of forest are very small. Data on the kind and number of soil invertebrates that inhabit the fir forests of the taiga zone are found only in papers by Dogel and Yefremov (2), Shilova (9) and Kozlovskaya (4).

This paper gives a description of soil fauna inhabiting different forest types in Middle Taiga on a carbonaceous moraine. Our attention is centered on earthworms whose importance in the biogeocenosis of forests is shown in publications by Zrazhevsky (3), Lindquist (12), Sibiryakova (8) and others. These papers also furnish data on other groups of soil invertebrates—those belonging to the mesofauna[1].

Our studies were carried on at the northern station of the AN USSR Institute of Forestry in the Kharovsk district, Vologda region.

A characteristic feature of this territory which is a subzone of the Middle Taiga is the shallowness of the carbonaceous moraine (60 to 100 cm.) and the large quantity of limestone fragments. In the elevated areas the clay loams of the moraine are coated with a layer of sandy loam up to 1 m. thick. The contour of the territory is slightly undulating.

This area is in the podzol zone. Environment (type of parent material, relief, drainage) has also brought about the extensive formation of humus or dark soil, peat-gley, and lowland peat—soils that are formed under conditions of high moisture and high carbonate content in the parent material.

The general distribution of various kinds forest and soil on this territory is as follow Elevations in relief are covered with stands fir and a shrubby-mossy undergrowth on d ferent varieties of podzolic soils. The typi vegetation on the lower slopes and over the mo even plains consists of fir trees with a grou cover of grass-moss over dark humus-gley soil the firs grow over grassy bogs of peaty gley a woody-grassy peat in the lower areas. The ban of small streams are lined with narrow strips pines growing in clay-peaty-gley soils. Here an there among the masses of fir are stretches sphagnum-pines on woody-sphagnum peat bog sometimes these sphagnum-pines cover lar areas.

The podzol soils under the forests of fir wit blueberry ground cover have a distinct podzol horizon directly under the forest litter. Th thickness of horizon A_0 is 5 to 7 cm., that of is usually not over 10 to 15 cm. The podzol stratum merges into a brownish-ochre illuvia metamorphic horizon. The parent material f podzol soils consists of carbonaceous morai clays with large admixtures of limestone frag ments; this causes the soil to effervesce whe HCl is introduced at a depth of about 100 cm.

Usually the podzol profile is in two sections its upper part is a coarser texture than i lower part. Both have a low humus content ap proximating 1% in horizons A_2 and B. The co tent of adsorbed cations in the upper horizo is 2 to 3 me. per 100 gm. of soil; deeper dow it increases to 10 to 20 me. In horizons A_2 an B_1 the cation saturation is 30 to 40%. In horizo B_2 it increases from 60 to 90% because of th carbonate content of parent material. Activ reaction in the upper horizons A_0 and A_2 of thes soils is acid (pH 4.3 to 4.7) and gradually b comes alkaline with increasing depth—the p is 7.3 to 7.8 at a depth of 100 to 150 cm.

In this type of forest, observations were r corded in three test plots, two on stands of f nd one on birch. An evaluation of these is given s follows:

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[1] Descriptions of the regions, soils and test plots are furnished by K. A. Gavrilov. The zoological part of the work was done by T. S. Perel under the guidance of M. S. Gilyarov.

N. P. Krivosheina, Z. V. Chadayeva, and N. M. Chernova participated in making larvae determinations. Preliminary determinations on collections for 1955–1956 were made by P. M. Rafes. Consultations on a number of questions were given by I. I. Malevich. The authors wish to express their thanks to all these people.

Test plot I, 10 fir + birch: 130 years, site quality III, stand density 0.7

Test plot II, 10 fir + birch + aspen: 110 years, site quality IV, density 0.8

Test plot III, 1st story. 9 birch, 10 pine + fir: 80 years, site quality II, density 0.8; 2nd story. 10 fir: 10 years

The underbrush in all these plantings is sparse onsisting of mountain ash. The floor cover consists mostly of blueberry, occasionally bilberry, Northern linnaea, maybush (Crataegus) and thers. The mosses are predominantly green, mostly *Pleurozium Schreiberi* which is dense under firs and sparse under birches. All the plots were located on the tops of hill-like formations.

Under the fir stands on green moss, dark clay loams and gleys form a thick (20 to 30 cm.) horizon of humus underneath the layer of forest litter. The forest litter has become peat and is 10 to 15 cm. thick. The horizon of cumulative humus changes rather abruptly to horizon B, reddish-brown in color. This horizon is usually more or less gleyed and is underlain with brownish-yellow clay loam with inclusions of limestone fragments. These soils effervesce from HCl applied at a depth of 60 to 70 cm.

Soils of peat and humus have a high content of organic matter. In the upper part of the profile, in horizon A_1, the organic matter content is 30 to 50%. At 30 to 40 cm. depth, it drops from 5 to 6%; then at 40 to 50 cm. depth it drops to only 0.5%. These soils are rich in exchangeable cations. They total 40 to 60 me. in the upper horizons. Hydrolytic acidity is relatively low; therefore, the cation saturation is rather high (85 to 90%). The active reaction of peat and humus soils is slightly acid in the upper horizons (pH = 5.5 to 6.5) becoming neutral or slightly alkaline in the lower horizons.

Observations on these soils were recorded for four test plots, two under firs and two under birches; the plots were located next to a hay meadow clearing on the edge of the forest near a railroad.

The plots can be described as follows:

Test area IV, 1st story, 10 fir: 180 years, site quality IV, density 0.7

Test area V, 9 fir + 1 birch: 130 years, site quality IV, density 0.9

Test area VI, 1st story, 10 birch + aspen + alder: 40 years, density 1.0; 2nd story, 10 fir

Test area VII, 1st story, 10 birch + aspen: 40 years, density 1.0; 2nd story, 10 fir

The underbrush in these plantations is rather sparse consisting of mountain ash, downy currant (Ribes), mezereon and honeysuckle. The forest floor cover is predominantly mixed grasses, northern aconite, spreading aconite and others, combined with the more typical plants of fir forests—blueberries, forest horsetail (Equisetum), Oxalis and others. The mosses are green clubmosses; most common is *Rhytidiadelphus triquertus*. In the birch forests, the mosses are poorly developed. In the depressions, there are occasional small beds of sphagnum moss.

Test Plot No. VII. The ground cover in the haymeadow consists of grasses, legumes and herbaceous plants. Chief among the grasses are those of compact growth habit, *Deschampsia caespitosa* and *Nardus stricta*; of the Leguminaceae, *Vicia crassa* and *Trifolium repens* are most frequent; of the herbaceous plants, occasional dense masses of *Rhinanthus major*, numerous species of *Euphrasia, Parnassia palustris, Sapsana communis* and others occur. There are several species of sedges. The mossy cover consists of green mosses usually on tree stumps.

All the test plots were located at the base of gentle slopes.

Test Plot VIII. Fir forest with Oxalis ground cover, over slightly podzolic clay loam, the podzolic areas visible in the form of whitish spots. Plantation consists of 9 fir + 1 birch: 65 years, site quality I, density 0.9. The undergrowth consists of mountain ash (rowan), cordate-leaved basswood, honeysuckle and wild rose (*Rosa canina*). The herbaceous cover is mainly Oxalis, blueberry and herbaceous weeds (hazelwort, goutweed and others). The mossy cover is not well developed. This plantation is located in the upper part of a flat slope.

Test Plot IX. Fir stand on mixed herbaceous and Oxalis cover; soil, humus-podzolic clay loam with a distinct humus-cumulative horizon and signs of podzolization such as found in humus soils. Composition of plantation: 9 fir + 1 aspen + occasional birch: 80 years, site quality II, density 0.8. Undergrowth consists of mountain ash. Herbaceous covering chiefly weeds (goutweed, monkshood and so on) occasionally blueberry and Oxalis. The mossy cover is slightly developed. The sample plot is located in the center of the incline of a hill-like elevation.

Test Plot X. Fir stand on blueberries and sphagnum over a peaty-podzolic gleyed clay loam underlain by a peaty layer about 20 cm. thick with a distinct podzolic horizon below the peaty layer. The lower horizons are gleyed. Composition: 10 fir + solitary birches: 130 years, site quality V, density 0.8. The undergrowth is sparse. The ground cover is sparse clusters of blueberry and horsetail. Heavy cover of green clubmosses along the elevations and sphagnum mosses in the depressions. The plantation covers an even plain bordering on a sphagnum swamp.

Test Plot XI. Fir stand on a grassy bog over peaty-gleyed soil with the peat 50 to 60 cm. thick. Under the peat is a grayish-blue gleyed stratum. The peat is mixed woody-herbaceous, well decomposed. The plantation consists of 10 fir: 170 years, site quality V, density 0.7. Species of swamp vegetation predominate in the forest floor cover. The moss covering is dense consisting of green clubmosses with spots of white sphagnum along the depressions. The plantation is located in a basin at the foot of a hill.

Test Plots I, IX, IV and XI. These are adjacent and located on the same slope of a hill. The combined test plots thus make up the ecological profile from podzol at the top of the hill down to the peaty-gleyed soil at the foot of it.

The water regime of the soils is of great importance to soil invertebrates. We must remember that all varieties of soil in a swampy region are subject to alternate periods of excessive and moderate moisture. The humus soils are likely to retain excessive moisture for longer periods than the podzolic soils. In dry seasons, the moisture content in humus soils is usually great and the water table is closer to the surface th in podzol soils.

TABLE 1

Species of earthworms and their occurrence

Species	Frequency of occurrence, %
Eiseniella tetraedra (Sav.) *f. typica*	2.1
Eisenia rosea (Sav.)	12.5
Allolobophora caliginosa (Sav.) *f. typica*	+[a]
Dendrobaena octoedra (Sav.)	48.9
Bimastus tenuis (Eisen.)	8.4
Octolasium lacteum (Oerley)	46.9
Sumbricus rubellus Hoffm.	+

[a] Those marked + were found only in the vegetable garden of the farmhouse.

Earthworms

Materials were collected in July and Augu 1957, by T. S. Perel. In making counts of t soil fauna occurring in Test Plots I, V, VI, VI VII, twenty-four soil samples were taken fro each, with the samples 50 x 50 cm. on the su face and 30 to 40 cm. in depth. Test Plots I IV and XI combine with Plot No. I into o ecological profile. From each of these three plot eight samples were taken. Four samples we taken from Test Plot VII. The material w sorted by hand. The material from those plo from each of which 24 samples were collecte was treated statistically.

The territory investigated contained seven sp cies of earthworms (Table 1). The species *All lobophora caliginosa* and *Sumbricus rubeilus* o curred only in cultivated soils. The *Eisenia rose* inhabits a very limited area (Tables 1, 3). Th species was found only in the vicinity of Kac nikovskii settlement, in a hayfield and in a vege table garden, on humus-gleyed clay loams. Th average frequency of occurrence of *E. rosea* i the hayfield was 24.5 ± 3.3 per 1 sq. m. Th *Biomastus tenuis* was present in only a fe samples (Table 1) in various habitats—peaty humus soils in the birch stand, in the stand o firs with ground cover of mixed herbs and club moss, in the hayfield, and in the podzolic soil o the stand of firs and blueberries. It was foun everywhere under conditions typical for thi species—in decayed wood, in piles of decompos ing plant residue, and among the mosses. Th *Eiseniella tetraedra* is an amphibian species, in digenous to locations with constantly excessiv moisture; it was found only in a swampy fir for est with a ground cover of grassy swamp vege tation over peaty-gley soil (Test Plot XI); occurred in three samples out of eight. The mos widespread over the territory of Severnay (Northern) Station are *Octolasium lacteum* an *Dendrobaena octaedra* (Table 1). The *O. lac teum* is known as a very moisture-loving species It belongs to the group of species that fee mainly on the humus contained in the soil (13 7). Franz (13) calls such earthworm specie "humus consumers", in contrast with species tha feed mostly on plant remains which he call "humus producers". The *O. lacteum* was absen

TABLE 2

pecies and numbers of earthworms in test plots with different ecological profiles

Species	I Fir-blueberry on podzol	IX Firs with Oxalis & herbs on peaty-podzolic soil	IV Firs with herbs and club-moss on peaty-humus soil	XI Firs with mixture of swamp vegetation on peaty gleyed soil
imastus tenuis	+	−	−	−
endrobaena octaedra	+	+	+	+
ctolasium lacteum	−	+	+	+
iseniella tetraedra	−	−	−	+
otal number per 1 sq. m.	5.5 + 1.3	8.5	7.0	8.0

nly in samples of podzol soils from the fir-overlueberry forest. It is of interest that in the test lot adjacent to the fir-blueberry plot, this speies was present in five samples out of eight Table 2) ; the planting in the adjacent plot conisted of firs on a mixture of Oxalis and herb rasses, over transitional humus-podzolic soils. he average numbers of *O. lacteum* in various ocations remained fairly constant, not exceeding 0 per 1 sq. m.

The size of *O. lacteum* varies greatly, dependng on conditions of habitat. In the peaty-hunus-gleyed soil under the fir stand with herbnd-clubmoss ground cover, worms of this species re noticeably larger than in birch plantations; hey are also larger than the specimens collected n hayfield soil (Table 6).

Dendrobaena octaedra is a characteristic inabitant of deciduous and coniferous forest soils nd was present in all the test plots. It occurred nuch more frequently in the podzol of the fir-n-blueberry forest, and in the peaty humus of he fir forest on mixed herbs and green moss, han in the humus soils of the birch stands (Tale 3). It was present in all the samples taken f hayfield soil.

The number of *D. octaedra* occurring in the ayfield equaled 92.6 ± 16.2 per 1 sq. m.; in the r stands on herbs and clubmosses (Test Plot No. V), it was 3.1 ± 0.4 per 1 sq. m.; in the fir tand on blueberry (Test Plot No. I) its freuency of occurrence is practically the same as he total (Table 4) because, aside from *D. octaera*, only two worms were found here. Both were of the species *B. tenuis*. In the humus of birch stands (Test Plots VI and VIa), the average number of *D. octaedra* specimens was about 1 per 1 sq. m.

The total number of earthworms in each of the forest plantations studied was approximately the same, less than 10 per 1 sq. m. everywhere (Tables 2, 4).

However, the mass weight of earthworms in the podzol of the fir-blueberry forest stand was several times less than in the peaty-humus soils of fir with herbs and clubmosses, less than in the

TABLE 3

Occurrence of earthworms in test plots[a]

Species	Frequency, percent				
	Podzol	Soils of peaty humus			
	I Fir with black-berry	V Fir with grassy plants and green mosses	VIa Birch forest	VI Birch forest	VII Hayfield
O. lacteum	—	66.6	75.0	52.6	48.0
D. octahedra	66.6	54.1	16.5	21.0	100.0
B. tenuis	one	one	—	one	34.7
E. rosea	—	—	—	—	69.1

[a] The data given are only for test plots; not less than 20 samples were taken from each plot.

TABLE 4

Average number and mass weight[a] *of earthworms per 1 sq. m.*

No. of test area	Forest type	Soil	Average number per 1 sq. m.	Mass, grams per 1 sq. m.
I	Fir with black-berry	Podzol Podzol	5.5 ± 1.3	0.6
V	Fir with herba-ceous-green-moss mixture	Peat-and-humus soil	8.5 ± 1.6	3.8
VI	Birch		5.4 ± 1.6	2.1
VIa	Birch		8.2 ± 1.1	2.0
VII	Hayfield		132.0 ± 18.9	9.7
VIII	Fir with Oxalis	Slightly pod-zolic	8	3.8

[a] The worms were fixed in 4% formalin, then weighed.

TABLE 5

Average numbers of earthworms in forest plantations

Species	Average numbers per 1 cu. m.			
	Peaty-humus soil			Slightly podzolic soil
	V Fir stand with herbs and clubmoss	VI	VIa	VIII Firs with Oxalis
		Birch stand		
O. lacteum	5.3 ± 1.5	4.2 ± 0.9	7.5 ± 1.1	6
D. octaedra	3.1 ± 0.4	single specimen	single specimen	2
B. tenuis	single specimen	solitary specimen	—	—

birch stand, and also less than in the slightly podzolic soil of the firs with Oxalis. This is because in the fir-blueberry forest, the worms are represented by a small species, *D. octaedra*, which inhabits forest litters, while in the birch forests and in stands of firs on herbs and clubmosses and on Oxalis the great mass of earthworms consists of large ones belonging to the *O. lacteum* species (Table 5).

A comparison of length and average weight of *D. octaedra* with *O. lacteum* is given in Table 6.

The total number of earthworms in the humus soils of the hayfield was 132 ± 18.9 per 1 sq. m. or about 13 times higher than the number in soils of forest plantations. The mass weight of earthworms was only 3 to 4 times greater in the first case than in the second (Table 4). This is primarily because about 70% of all the worms found in the hayfield belonged to *D. octaedra* species. In addition, worms of the species *O. lacteum* are of much smaller size and average weight in hayfield soil than the specimens found in the fo est samples (Table 6).

This shows that within the limits of the ar studied, the specific composition of a plantatio does not have any noticeable effect on the di tribution of *O. lacteum*. This species depen primarily on the water regime and type of so (Table 2). The absence of *O. lacteum* in th podzols of the fir-blueberry forest (Test Plot is evidently connected with low content of o ganic matter in the soil, a comparatively hig acidity (according to Baltzer [11] this specie is not found in acid soils), and a less favorab water regime.

The *O. lacteum* was rather numerous in th slightly podzolic soils of the fir stand with Oxal (Table 5). Apparently, the degree of podzoliza tion of the soils influences the distribution of *lacteum*. This species was always present on hu mus soils.

On the other hand, the *D. octaedra* depend greatly on the specific composition of a planta tion. Worms of this species were more numerou under fir than under birch plantations (Tabl 3). There was little difference in number and oc currence of *D. octaedra* in a fir-blueberry fores over podzol than its number and occurrence i a fir stand with herb-clubmoss cover over peaty humus soil. It is possible that *D. octaedra*, a spe cies indigenous to forest litter, is more depend ent on the type of plantation than on soi characteristics. Zrazhevsky (3) arrived at a similar conclusion in his analysis of the distributio of *D. octaedra* in the forests of the Ukraine.

A comparison of results obtained from soi studies on Kotlassky forest farm (4), located i similar climatic and soil conditions, disclose many similarities. The number of earthworm in the forest plantations of Kotlassky fores farm did not exceed 16 per 1 sq. m.

At the Kotlassky forest farm, the earthworm

TABLE 6

Average weight and length of matured worms of species D. octaedra and O. lacteum, taken from fixed materia

Type of soil	Peaty-gleyed humus				
Test area	V Firs with a ground cover of herbaceous plants and green moss		VIa Birch	VII Hayfield	
Species	*O. lacteum*	*D. octaedra*	*O. lacteum*	*O. lacteum*	*D. octaedra*
Average weight, mg.	1200	130	645	365	77
Average length, mm.	93	41	77	50	34

TABLE 7

Average numbers of myriapods and insect larvae, recorded by test plots per 1 sq. m.

Invertebrates	Podzol			Peaty-humus soil				VIII Fir with Oxalis on slightly podzolic soil	X Fir with blueberries and sphagnum moss, on peaty-podzolic soil
	I Fir with blueberries	II	III birch	V Fir with herbaceous and green-moss forest floor	VIa Birch forest	VI	VII Hayfield		
iptera (larvae)	10	8	5	10.6	4	7	14.5	15	1
ire worms	11	15	5	9	+	+	6	15	9
ther larvae from the orders:									
Coleoptera	2	3	3	2	+	+	47.1	3	—
Chilopoda	7.5	9	8	6.5	2	4.3	2	3	7
Diplopoda	2.5	—	—	5	+	+	+	7	

+ — in single specimens

e represented by the species *O. lacteum* and . *octaedra*. These species were also most com- on at the Kharovsky forest farm.

A comparison of our own data with those ailable in literature on the forest regions of ostroma (5), Ivanovka (1), Moscow (6) and veral others, shows that the number of earth- orms occurring in the Kharkov forest farm in e Vologda district is very small and the vari- ies very few.

Other Groups of Soil Invertebrates[2]

Of the other invertebrate groups found in soils the area investigated, most common were the rvae of Diptera, beetles, and myriapods. The equency of occurrence of Diptera larvae in the stand with mixed herbs and clubmosses (Test lot V) was 62.5%; in birch stands on humus est plots VI and VIa) and in firs on blue- erries (Test Plot I), it was about 80%; in the ayfield it was 69.5%. Table 7 gives a general ea of their numbers.

The varietal makeup of Diptera larvae is ther large (Table 8). Most numerous are Dip- ra larvae of the Rhagonidae family (*Rhagio* .). An interesting fact is that the Rhagonidae e absent in the blueberry-sphagnum fir stand Test Plot X); instead, the Empididae are pres- t here and not in the other test plots.

In forest plantations, the larvae of beetles are chiefly wireworm larvae (*Elateridae*). These have been found in almost all the test plots (Table 8). The occurrence of wireworms in the fir-with-blueberry stand (Test Plot No. I) is 75%; in the fir with herbs and clubmoss (Test Plot V), it is 62.5%; in stands of birch over humus soil, it is less than 20%. Numerical data are given in Table 7.

A much higher number of wireworms was recorded for firs with mixed herbs and clubmoss (Test Plot V), firs with blueberries (Test Plot I), and firs with blueberries and sphagnum than the number in birch stands. The variety was *Eanus costalis* (*Selatosomus costalis Payk*), not found in birch forests. Larvae from other families of the Coleoptera order were much less frequent in samples taken from forests, usually solitary specimens (Table 7).

In soil samples from the hayfield, the larvae of beetles were more varied (Table 8). The highest average number (38.3 per 1 sq. m.) belongs to the larvae of beetles that have not been exactly identified so far. In the hayfield soil, wireworms were found in only 30.4% of the samples. They are represented by species from the genera Corymbites and Agriotes, not found in samples from forest soils. Average numbers of wireworms are given in Table 7.

Myriapods were found in all the test plots. The Chilopoda are represented by families Lithobidae and Geophilidae. The geophils were present only in the hayfield; here they were rather numerous. On the other hand, species of the Lithobiidae family were recorded in only one sample. Of the Diplopoda, there were represen-

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[2] For descriptions of other groups of soil in- ertebrates, in addition to collections made in 1957, e used the collections made by K. A. Gavrilov in eptember 1955–1956 from test plots I, II, III, IV, III, IX, X and XI. Four samples were taken from ch of these plots.

TABLE 8

Species list of Diptera and Coleoptera larvae found in the soils of Kharovsky forest farm[a]

Soil	Podzol			Peaty-humus					Slightly podzolic	Humus-podzolic	Peaty-podzolic	Peat gley
									Fir forest			
Type of forest	Fir on blackberry		Birch	Fir on herbaceous and green-moss floor		Birch		Hay-field	Oxalis	Oxalis-herbaceous forest floor	Black-berry and sphagnum moss	Herb ceou anc swan plan
Test plot number	I	II	III	IV	V	VI	VIa	VII	VIII	IX	X	XI
Diptera												
Bibionidae	–	–	+	–					+	–	–	–
Tipulidae	–	–	–	+					+	+	–	+
Rhagionidae	+	+	+	+					–	+	–	+
Empididae	–	–	–	–					–	–	+	–
Dolichopodidae	–	+	–	–					–	–	–	–
Psilidae	–	–	+	–					–	–	–	–
Cyclorrhapha	–	+	–	–					+	+	–	+
Coleoptera												
Byrrhidae	–	–	–	–	–	–	–	+	–	–	–	–
(gen. sp.)	–	–	–	–	–	–	–	+	–	–	–	–
Curculionidae	+	–	+	–	–	+	–	+	–	–	–	–
Carabidae	+	–	–	–	+	+	+	+	–	–	–	–
Staphylinidae	–	–	–	–	+	+	–	+	–	–	–	–
Cantharididae	+	+	–	–	+	–	–	+	–	–	–	–
Elateridae	+	+	+	–	+	+	+	+	+	+	+	–

[a] The list of species for larvae of Diptera includes only the materials collected in 1955–1956.

tatives of Julidae, Polydesmidae, and Polyzonidae families. Average numbers of myriapods are given in Table 7.

Conclusions

1. All the soil varieties in the investigated areas are periodically subject to excessive moisture. This characteristic of the moisture regime is reflected in the makeup of soil fauna. At the Kharovsky forest farm, the most common species of earthworms are *Octolasium lacteum* and *Dendrobaena octaedra* which are swamp-tolerant. From the other groups of invertebrates, those predominating in soils of forest plantations are the larvae of Diptera and wireworms. As Shiperovich (10) states, this is typical of forests that have high soil moisture.

2. The numbers of earthworms found in the forest plantations of Kharovsky farm are small —less than 10 per 1 sq. m.

3. The mass weight of earthworms in all the types of forest investigated that grow over peaty-humus soils is expressed in similar figures. The species of the worms found are similar.

4. The mass weight of earthworms found in podzol soils of the fir-blueberry forest is several times less than elsewhere, because here only th small litter-inhabiting species *Dendrobaena octaedra* and *Bimastus tenuis* were found. Th mass of worms is much greater on the slightly podzolic soil of the fir-Oxalis forest than in th blue-berry-fir forest. Here the worms are represented by the species *O. lacteum* and *D. octaedra*.

5. The *D. octaedra* species whose habitat i forest litter is much more frequent in fir than in birch forests. The distribution of *O. lacteum* within limits of the region investigated is not noticeably influenced by the varieties that make up the planting.

6. The average number of larvae of beetles found in forest plantings was not over 18 per 1 sq. m.; average number of Diptera larvae was not over 15 per sq. m.

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SHORTCOMINGS IN THE ELUCIDATION OF SOILS IN THE SECONDARY SCHOOL COURSE IN GEOGRAPHY

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SOILS are inseparable components of every natural zone. Therefore, geography encompassing such topics as natural conditions and zones cannot ignore the soil.

The secondary school course in geography must familiarize students with the soils of various zones and with measures to raise the productivity of agriculture.

Some information about soils is given to students in the biology course and in practical agricultural work. However, they are only acquainted with soils as a substratum on which plants grow and receive practice in soil tillage. It is the duty of the geography teacher, however, to show soils as an element of the landscape, point out their geographic distribution, characteristics of the natural conditions under which they are formed, and different ways in which man treats the soil to increase its fertility. Elucidation of these questions is especially necessary in order to shape the dialectic world outlook of the students.

In the geography courses (8) the section "Primary Course in Physical Geography" (for the fifth grade) contains no reference to the soil, even though the weathering of rocks (including that by living organisms) and control measures against gullies are mentioned. There is a separate section on natural zones of the world, but the soil is not mentioned (there either).

In the fifth grade textbook (4) the definition of soil formation is given only in connection with the topic "Weathering" and in this lesson "steppe zone" chernozems are mentioned superficially. Before taking up natural zones, the textbook states: "Every zone is characterized by certain properties of climate, vegetative and animal worlds" (pp. 125), but soils are not mentioned at all. Soils are mentioned in several places in the manual on methods for the fifth grade (6), but the remarks are too superficial.

Khodorovich recommends in his article (11) for the fifth grade a nature study trip on the topic of "natural zones", which should acquaint the students with the natural zone in which they live. Although he envisages the students' gaining familiarity with the vegetation (more specificall with trees and bushes), he mentions the sc only to explain the effect of the forest on it.

One section in the course "Physical Geograph of Various Parts of the World" (sixth grade provides information on natural zones in variou parts of the world. It would seem that acquaintance with soils should be absolutely necessar But the explanatory note leaves no doubt tha soils are also omitted here. The course for th sixth grade includes a combined nature stud trip to acquaint the students with the natura conditions of a given place. For some inexplicable reason this course provides only for familiarization with the relief, waters, and vegetation How is it possible to exclude soils, parent materials, the climate, and the animal kingdom? A study of animals in the zoology course does no preclude its being considered in the geograph course as a part of the general complex of natural conditions. To conduct a combined natur study trip and to ignore the soil and parent materials is incomprehensible. It is so easy to observe the formation of the soil and parent materials of which the particular area is made up It is clear that a field trip that excludes the observations of parent materials, soils, climate, and animals cannot be complete, as it does not acquaint the students with all interrelated natura conditions. It is therefore very damaging to the study of geography and to formation of the dialectic world outlook in students.

Yefremov's (3) article helps the teacher to conduct a combined nature study trip for the sixth grade. He states correctly that "the teacher's duty is to show the students nature as a single unit whose separate parts are interrelated". Thus, he envisages here, despite the program, observations of parent materials. The author points out that the materials on zoology may be also included (however, he should have said—they *must* be included), but observation of the soil are not mentioned in the field tri program. Moreover, the word "soil" is not use at all. How can he speak about a single unit i he artificially excludes such an important com onent as the soil cover, even though he recomends observations of parent materials and llies?

The sixth grade textbook (10) adheres to the ogram almost completely. In only a few places there a mention of the soil. Only once in the xtbook is a soil group named (chernozem soils the Asia steppe zone); and yet a soil group the basic taxonomic unit characterizing the ost essential properties of soils.

In the section of the seventh grade course Geography of the USSR", we find a topic "soil-egetative zones of the USSR". In connection ith the study of the separate districts of the SSR, provision has been made for acquaintance ith the soils of every district (for some reason ils are not mentioned in the chapters "Ural" d the "Far East").

The textbook (12) characterizes the soil-vegetive zones but gives a short description of the ils for only some of the zones. In most cases is characterization is not sufficient to provide understanding of the basic measures needed increase soil productivity (for example, limg, use of gypsum, conservation of moisture, d so on). And yet, this knowledge is absotely necessary for the section "Economic Gegraphy of the USSR". The textbook gives the ncept of vertical vegetative zones, but does t mention vertical soil zones. In connection ith the description of separate districts of the SSR, soil data are given in the section "Cliate and Vegetation," but not for all the reons and only for a portion of their territories. ils are sometimes referred to without mentiong their soil groups (for example: "the southern rt of Central Asia is entirely covered with rtile loess soils"). Soils are often mentioned ly in passing. Thus, there is no system in aracterization of the soil cover.

In the section of the course "Economic Geogphy of Foreign Countries", the clarification the natural conditions of every country is ven. Consequently, this requires information on ils. The textbook (5) gives a short characteriation of the soil cover of many countries, but ils are not mentioned in the description of eland, Portugal, Sweden, Norway, Iceland, ongolian Peoples' Republic, Korea, Burma, hilippines, Japan, Afganistan, Iran, Brazil, and rgentina. For some countries (Turkey, Italy, reat Britain, Rumania, Bulgaria, Yugoslavia, rance, Germany) a soil description, often very superficial, is given only for a portion of their territory. In the case of several countries, instead of naming their soil groups some of their properties are mentioned: texture (Denmark), parent material (Mexico), soil quality (southeastern Australia), and so on. These data are valuable, but the soil groups encountered should have been given first.

The section of the course "Economic Geography of USSR" describes the natural conditions in all the regions (with the exception of the Urals, for some unknown reason). In several cases, the significance of these conditions for agricultural development is evaluated. This evaluation together with a soil evaluation should have been given for all the regions.

The textbook of economic geography of the USSR while describing regional natural conditions gives a short characterization of the soil (1). The peculiar natural conditions influencing the type of agriculture in a given region are discussed. Unfortunately, these data are not given for all the regions. Soils in the northern part of northwest RSFSR, the northeast portion of European USSR, eastern Siberia, Azerbaijan SSR, and the central Asian republics are not mentioned. We merely find references to a large bog area in the western portion of European USSR and to the existence of fertile soils in the Far East.

Geography textbooks contain several errors in explaining soil cover. The lack of a world soil map in atlases and in map supplements of textbooks is a great shortcoming. A wall map of world soils is non-existent. It is therefore absolutely necessary to compile and publish a world soil map for secondary schools which will be used in teaching geography along with the maps that reflect other natural conditions on the continents.

It is absolutely necessary to add soil maps to the "Geographical Atlas for the fifth and sixth grades of secondary school", thereby supplementing the existing schematic world maps and charts of continents reflecting natural conditions.

All this necessarily leads us to conclude that there are major shortcomings in the elucidation of soils, natural conditions, and natural zones in the secondary school geography course. They are particularly pronounced in the chapters "Elementary Course in Physical Geography" and "Physical Geography of Various Parts of the World".

We might agree on the need to shorten the material included in the textbook, but we cannot sanction the exclusion of soil data, for without it students cannot fully understand the natural zones.

The nature study trips of the sixth grade are very important; observations of parent materials, climate, soil, and animals must definitely be included. Elementary ideas of morphological properties of the soil must be given, since in the eighth grade the students examine soil profiles in detail during their practical agricultural work. During the trip it is imperative to acquaint the students with the natural conditions of the locality and their interrelationship.

The following basic stages of soil knowledge should be planned for the secondary school geography course:

In the fifth grade, the topic "Weathering" should include the definitions on soil formation, soil, and soil variants. In describing each zone the prevalent soil group should be mentioned together with a short explanation of its most characteristic properties reflected in its nomenclature.

In the sixth grade while explaining the natural zones of continents the teacher should gradually set forth the factors of soil formation and the effect of man's activity thereon. The results can be pointed out during the field trip. When studying the soil zones of continents the basic soil groups found in every zone should be pointed out.

In the seventh grade, the study of USSR geography should include information on main soil subgroups and their basic properties. This would prepare the students for economic geography of the USSR. While studying the chapter "Economic Geography of Foreign Countries" students should obtain brief descriptions of the soil in every country. While studying the economic geography of the USSR besides data on the soil of every region, students should get some idea of the measures to increase fertility, dependent on natural and, above all, soil conditions. The students' attention should be called to the need of accumulating and retaining moisture in arid regions and of controlling erosion. Students must be informed about the districts that need a great deal of fertilizer. This will all be a part of the larger task required to deliver school geography from its wretched state, as noted by Saushkin (9).

Conclusions

1. Soil is the most important, inseparab component of every natural zone. Therefore, description of natural zones is not complete u less the soils are mentioned.

2. The survey of the curriculum and textbook of geography in secondary schools shows marke defects in elucidating soils, natural condition and natural zones. Natural zones are often d scribed without mentioning soil. A world so map in atlases, or of wall-size is non-existent.

3. All these things have a harmful effect c the development of a dialectic world outlook b students, on their understanding of nature as single unit, and on polytechnical training.

4. The report outlines the main stages familiarizing students with soils in the geograph course of secondary schools.

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Chronicle

REPORT OF THE LATVIAN BRANCH ALL-UNION SOCIETY OF SOIL SCIENTISTS FOR 1957

K. Krumin'sh

THE Latvian Branch of the All-Union Society of Soil Scientists, which was organized Janary 23, 1957, has 53 members. The following esearch was conducted in the period under reiew. The classification and nomenclature of Latian SSR soils were detailed and standardized ith the Commission on Soil Classification, Sysematization, and Nomenclature; our suggesons and some corrections of soil classification f the northern non-chernozem zone were submitted to the commission.

A new project was developed relating to the ualitative appraisal of Latvian SSR soils (K. rivkalns, K. Tsirulis, and Ya. Kaurats). The oil scientists began to test this project and put into practice in the fall of 1957. Seven soil cientists (Brivkalns, Tsirulis, Maldavs, Skuyans, nd others) helped to organize courses sponsored y the Ministry of Agriculture of the Latvian SR designed to improve the skill of soil sciensts. About 20 soil scientists attended these ourses.

Six members of the society (Ayzupiyete, Brivalns, Gaross, Rinke, and others) lectured and onducted practical work in connection with the ourses organized for workers in the agricultural-hemical laboratories of machine and tractor ations. These courses were designed to improve he skill of laboratory technicians and were atended by 40 people. Workers in the Administraon of Land Use, Ministry of Agriculture, Latan SSR held more than 150 consultations with the agronomists on the questions of soil cartography and appraisal.

Two scientific conferences were organized, the first in May, 1957, on soil cartography and appraisal (40 people participated), and the second in December, 1957, on soil biology (50 people participated). At the December conference two reports were read: 1. Achievements in the investigation of soil fauna in the Latvian SSR. (V. Eglitis); and 2. Achievements in the investigation of soil microflora in the Latvian SSR (A. Kalnyn'sh).

Two conferences were held in February, 1957, on soil nomenclature and classification in connection with the plenum of the commission taking place in Moscow on February 5–7.

In connection with soil investigations, field trips and expeditions were organized: 1—in the Siguldskiy district to verify the classification and nomenclature of soils in this region (30 people participated), and 2—to check a new project on the qualitative evaluation of soils. For this purpose three trips were made to the Yelgavskiy, Erglyu, Kraslavskiy, and Preyli districts.

The Board of Directors of the Latvian Branch of the All-Union Society of Soil Scientists held meetings at least bimonthly.

To prepare the general report for the convention of the All-Union Society of Soil Scientists, the Latvian branch sent local materials in Russian on the systematics and nomenclature of Latvian soils to the organization committee of the society.

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